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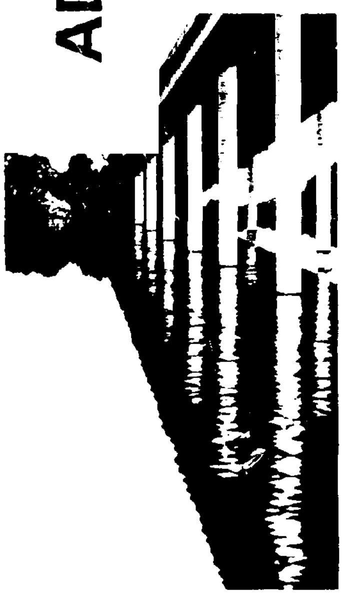

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SEASONAL BIOMASS AND CARBOHYDRATE DISTRIBUTION IN WATERHYACINTH: SMALL-SCALE EVALUATION

by

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A better understanding of aquatic macrophyte growth cycles and identification of physiological weak points in those cycles are essential for improving the effectiveness of present control techniques of nuisance aquatic vegetation. Application of control tactics at weak points in the target plant's growth cycle should maximize control effectiveness.

The objectives of this study were to identify potential physiological weak points in waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) based on seasonal carbohydrate allocation.

Waterhyacinths were grown in outdoor tanks at the US Army Engineer Waterways Experiment Station, Vicksburg, MS. Uncrowded, open-water conditions were maintained by periodic removal of plants to allow room for continuous ramet production. Monthly plant samples, obtained from June 1987 through November 1988, were separated into plant parts (leaves,

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petioles, membranes, stem-bases, stolons, roots, and inflorescences) to measure carbohydrates (free sugars, starch, and total nonstructural carbohydrates (TNC)) and dry weight in each structure. Data were analyzed to compare levels of carbohydrates and dry weight among plant parts in each month and to evaluate seasonal changes in these parameters for each plant part.

May/June and late October were the two periods of extensive ramet production. Maximum biomass was measured in early to mid-September. Peak flowering occurred from late August to early September. Dry weight proportion of leaves plus petioles was in the order mature *J* old *J* young. Dry weight proportions of mature and old petioles were often greater than those of mature and old leaves, while the reverse occurred in young petioles and leaves. Roots accounted for a higher proportion of plant weight (23.0 to 38.8 percent) in blooming and postblooming plants than in preblooming plants (8.1 to 22.3 percent). Significant seasonal changes in dry weight were found in leaves, petioles, membranes, and stem-bases.

Highest carbohydrate levels were found in stem-bases from July through November, and in mature leaves in other months. Roots and young petioles had lowest concentrations of starch as compared with other plant parts. Significant seasonal changes in carbohydrates were observed in mature leaves, young and mature petioles, stem-bases, and stolons. Blooming rachises contained the highest level of free sugars (22.8 percent) found in the entire plant. The TNC of whole plant analysis ranged from 3.4 to 9.6 percent.

Waterhyacinths store maximum carbohydrates in the stem-base during the September to October period. Starch and sucrose were the main components of carbohydrate reserves in stem-bases.

Information on seasonal biomass and carbohydrate distribution demonstrates the important role of stem-bases in the winter survival of waterhyacinth. Potential weak points in the growth cycle of waterhyacinth include the period shortly before mid-September or mid-October, when plants are actively translocating carbohydrates to stem-bases, and in early spring, when weather is warm enough for young ramet emergence and carbohydrates in stem-bases are low.

PREFACE

This research was sponsored by the Headquarters, US Army Corps of Engineers (HQUSACE), Directorate of Civil Works, through the Aquatic Plant Control Research Program (APCRP). Funds were provided under Department of the Army Appropriation No. 96X3122 Construction General. Technical Monitor for the HQUSACE was Mr. James W. Wolcott. The APCRP is managed by the US Army Engineer Waterways Experiment Station (WES).

The Principal Investigator for this work unit was Dr. Howard E. Westerdahl, Environmental Research and Simulation Division (ERSD), Aquatic Processes and Effects Group (APEG), WES. The study was conducted and the report prepared by Drs. Kien T. Luu and Kurt D. Getsinger, APEG. Dr. Luu was employed by the WES under an Intergovernmental Personnel Act agreement with the University of Tennessee. Laboratory assistance was provided by Ms. Cindy Waddle, Ms. Cindy Teeter, Mr. Ed Wilkerson, and Mr. David Stuart, APEG. Dr. C. J. Nelson and Mr. W. G. Spollen, University of Missouri-Columbia, provided technical advice for the thin-layer chromatography procedures. Mr. Dennis L. Brandon, Contaminant Mobility and Regulatory Criteria Group, ERSD, assisted with statistical analysis of the data. Reviews of this report were provided by Dr. R. Michael Smart and Dr. Westerdahl, APEG. The report was edited by Ms. Jessica S. Ruff of the WES Information Technology Laboratory.

This investigation was performed under the supervision of Dr. John Harrison, Chief, EL; Mr. Donald L. Robey, Chief, ERSD; and Dr. Thomas L. Hart, Chief, APEG. Manager of the APCRP was Mr. J. Lewis Decell, EL.

Commander and Director of WES was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

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CONTENTS

<u>SEASONAL BIOMASS AND CARBOHYDRATE DISTRIBUTION IN WATERHYACINTH: SMALL-SCALE EVALUATION</u>

PART I: INTRODUCTION

<u>Background</u>

1. Waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) is one of the worst nuisance aquatic plants in the southern United States and in the tropic and subtropic regions of the world (Holm 1969, Holm et al. 1977). This floating perennial interferes with water uses by causing direct obstruction to navigation, impeding waterflow in irrigation channels, degrading water quality for domestic use, and reducing outdoor recreation. The plant provides habitat and food for several harmful insects and for vectors of diseases such as malaria, encephalitis, and filariasis (Dassanayke 1938, Burton 1960, Wilson 1967, Sucharit et al. 1981).

2. Research on waterhyacinth management has focused on mechanical, chemical, and biological control techniques. Each control method has its own advantages and disadvantages, in terms of time, effort, cost, and environmental consequences on one hand and efficacy on the other. Perhaps the most logical approach to manage waterhyacinth is to integrate all available control measures. For example, sublethal doses of chemicals can be advantageous in increasing the susceptibility of waterhyacinth to biocontrol agents (Charudattan 1984).

3. Whatever control methods are involved, proper timing of application is often a key for success or failure in aquatic plant management. A better understanding of aquatic macrophyte growth cycles and identification of physiological weak points in those cycles are needed to improve the effectiveness of present control techniques. A physiological weak point is a period during the growth cycle when a plant is least likely to recover following the application of a control method. Application of a control tactic during this period should therefore maximize its overall effectiveness. Once weak points are identified, they must then be associated with specific growth cycle events, morphological characteristics, or environmental cues. These latter characteristics can then be used as management guideposts, which would allow field personnel to predict the optimum time for implementing specific control

actions. In other words, used in this manner, weak points become control points in the growth cycle of a target plant.

4. Carbohydrate allocation has been used to identify physiological weak points in the life cycles of terrestrial species. In forage and turf areas, weak points were identified in order to protect and maintain the plant vigor of early spring growth (Sullivan and Sprague 1943; Ward and Blaser 1961; Davidson and Milthorpe 1965; Keen 1969; Youngner 1969; Wilson and Robson 1970; Smith 1973, 1975; Booysent and Nelson 1975). Inversely, in plant control areas, these physiological weak points were used as control points to suppress spring growth or eradicate the target plant. One control technique is to disrupt the normal source-to-sink translocation of carbohydrates that precedes winter dormancy. For example, mowing of shoots in the fall prevents accumulation of below-ground carbohydrates in perennials by interrupting their translocation from shoots to roots and rhizomes. Without sufficient carbohydrate reserves, plants are more susceptible to winter injury or death, and spring growth is diminished.

5. Spring growth, when underground reserves are low, is also a critical period during which a control method, such as repeated mowing, is most effective for controlling perennial grass species (Klingman, Ashton, and Noordhoff 1975). Studies in Missouri revealed that greatest reduction of western ironweed (*Veronia baldwinii* Torr.) occurred with multiple mowing when initial mowing was made in May, when rapid growth was taking place, presumably at the expense of carbohydrate reserves (Peters and Lowance 1978). A report from Kansas noted that carbohydrate reserves in western ironweed were low at the bud stage, and mowing at this stage reduced ironweed stems 45 percent (Aldous 1930). Researchers from Wisconsin pointed out that mowing when carbohydrate reserves are low reduces the vigor of perennial plants and, if repeated often, may eventually kill the plants (Graber et al. 1927).

6. As do their terrestrial counterparts, perennial aquatic plants may rely on stored carbohydrate reserves for survival through winter and initiation of spring growth. In addition, recovery from periods of stress caused by temperature fluctuations, drought, nutrient depletion, diseases, and control tactics may also be dependent on carbohydrate reserves. Linde, Janisch, and Smith (1976) identified a relationship between carbohydrate reserves and growth cycle events in cattail (*Typha glauca* Godr.). When the pistillate spike was lime green in color and the staminate spike appeared dark green,

carbohydrate reserves were at their lowest level in the plant. The color of the pistillate and staminate spikes marked the optimum time for implementing control techniques.

Carbohydrates in Waterhyacinth

7. While considerable information exists on the biology of waterhyacinth, few data are available regarding carbohydrate allocation in this species (Pesacreta and Luu 1988). The few published reports of carbohydrate levels in waterhyacinth have dealt largely with carbohydrates as an indicator for the potential of methane gas production or animal feed (Penfound and Earle 1948; Boyd 1969; Tucker 1981a,b; Tucker and DeBusk 1981).

8. Studies of Florida populations showed that total nonstructural carbohydrates (TNC)* in waterhyacinth were not significantly affected by plant densities (Tucker 1981a) or by the ionic form in which nitrogen was supplied (Tucker 1981b). Concentration of TNC varied seasonally, and the changes appeared to be related to seasonal differences in growth rates. Lowest TNC occurred in winter, at the time of lowest growth rates. As dry matter productivity increased in warm weather, TNC increased (Tucker and DeBusk 1981). Examinations of starch density in plants from Louisiana (Penfound and Earle 1948) indicated that waterhyacinth contained high levels of starch with the greatest amount in rhizomes (stem-bases), intermediate amounts in stolons, peduncles, and leaves, and the least amount in roots. Rhizomes stored most of the starch, and the amount of starch diminished with distance from this organ.

Objectives

9. The objectives of this study were to determine the seasonal allocation of dry weight and carbohydrates among plant structures and to identify potential physiological weak points (based on seasonal carbohydrate allocation) in the growth cycle of waterhyacinth.

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* Total nonstructural carbohydrates can be separated into two fractions: free sugars (monosaccharides and disaccharides, such as glucose, fructose, maltose, sucrose, etc.) and reserves (polysaccharides, such as starch, fructan, etc.). Free sugars are readily available for metabolism, while reserve components are typically stored in stem-bases, tubers, turions, rhizomes, stolons, crowns, and roots.

Materials and Methods

10. Three replicate waterhyacinth populations were initiated from uniformly sized ramets (daughter plants) and cultured outdoors in epoxy-coated, wooden tanks (240 × 76 × 76 cm). A 10- to 20-percent Hoagland solution was used as a nutrient source (Hoagland and Arnon 1950). Daily maximum and minimum temperatures of air and water were recorded by self-registering thermometers.

11. Plants were grown for several months prior to sampling for biomass and carbohydrate determination. Uncrowded, open-water conditions were maintained by periodic removal of plants from part of the water surface area to allow room for continuous vegetative reproduction. Following removal of plants, the nutrient solution was replaced in all tanks. Monthly plant samples were collected from June 1987 to November 1988 to measure seasonal changes of carbohydrates and dry mass in different plant structures. A 0.25-m^2 frame was placed in the waterhyacinth stand at a point that estimated the actual proportion of young and mature plants in the population at the time of sampling. Plants enclosed within the frame were harvested and separated into different structures: stem-bases, roots, inflorescences, stolons, membranes, leaves, and petioles (Figures 1 and 2). Prior to monthly harvests, seasonal growth characteristics (e.g., plant size, petiole type, ramet production, flowering, etc.) were recorded.

12. Leaves and petioles were separated by age class into young, mature, and old categories. Young leaves were defined as the top two leaves of each plant; old leaves were leaves with partially yellow blades and necrotic tissue. During winter, plant structures (except stem-bases) were frost-burned or senescent, making it impossible to distinguish and separate structures. Therefore, during February and March, the existing plant mass consisted of living stem-bases and dead material.

13. In addition, separate samples of blooming and wilted (5- to 7-day-old) inflorescences were sampled to determine the change in carbohydrates during and following blooming. A total of 170 blooming inflorescences and 164 wilted inflorescences were randomly sampled at six times (from 14 July 1987 to 23 September 1987) and considered as six replications. Inflorescences were separated into three parts: rachises, florets, and peduncles (Figure 2).

14. Plant samples were dried in a forced-air oven at 58° C to a constant dry weight. Dried plant materials were ground to pass through a 1-mm screen in a Cyclone Sample Mill (Udy Corporation, Boulder, CO) prior to carbohydrate analyses. Total nonstructural carbohydrates were determined by a modification of the procedure of Swank et al. (1982). Extracts for TNC (starch, hydrolyzed sugars, reducing sugars) were incubated for 15 min at 55° C with one unit of amyloglucosidase (Sigma No. A3042) per millilitre to achieve complete starch hydrolysis before assaying for reducing sugars (Nelson 1944). Free sugars (hydrolyzed and reducing) were also determined on extracts not incubated with amyloglucosidase.

15. Sugar species of reserve carbohydrates were identified by thin-layer chromatography (TLC) based on the methods of Lato et al. (1968), with minor changes (Streeter and Bosler 1976). Aliquots of samples were applied to silica gel TLC plates (Fisher Redi-plate 06-600A) and developed in an ascending manner for 4 hr using 1-butanol:acetic acid:water (2:1:1) as irrigant 1, or using isopropanol:water (4:1) as irrigant 2. Following chromatography, plates were air-blown dry before spraying with visualization reagent; the plates were air-blown dry again and then heated at 85° C for 10 min. The visualization reagent for the procedure with irrigant 1 was urea-phosphoric acid (Wise et al. 1955), which formed a blue color with ketoses. The visualization reagent for the procedure with irrigant 2 was aniline-diphenylamine (Sigma No. 8142), which formed a pink color with ketoses and a blue color with aldoses.

16. The percent distribution of dry weight for each plant structure is expressed as the percentage of dry weight in that plant structure/total plant dry weight. The summation of percent dry weight distribution of all plant structures is equal to 100 percent. The concentration of carbohydrate is expressed as grams per 100 g dry weight.

17. A completely randomized design with three replicates (three tanks) was used. Treatments were different sampling dates and different plant structures. Measured parameters included concentration of carbohydrates (free sugars, TNC, and starch) and dry weight distribution in different plant parts. The Waller-Duncan test (Smith 1978, Steel and Torrie 1980) was used to separate the effects of treatment means.

PART II: RESULTS AND DISCUSSION

Growth and Seasonal Biomass Production

18. The seasonal biomass production of waterhyacinth grown under the experimental conditions of this study is depicted in Figure 3. In March, the amount of overwintering, living biomass was small and consisted of a few stem-bases, surrounded by masses of necrotic tissue. As the weather warmed in April, young ramets emerged from the surviving stem-bases, and biomass slowly increased. Biomass continued to increase during May and June, a period marked by maximum vegetative reproduction. Ramets were 5 to 15 cm in diameter, less than 15 cm tall, and had leaves with bulbous petioles during this period.

19. In July, plants were approximately 20 cm in height and possessed a mixture of bulbous leaves, located at low positions on the stem, and nonbulbous leaves, at higher positions on the stem. Although ramets were still being produced, the rate of production had slowed. Crowded conditions began to occur at this time due to the growth of individual plants and young ramet production, and biomass continued to increase.

20. By August, most plants were 25 to 30 cm tall, and biomass had more than doubled the June level. Crowded conditions resulted in the shading and senescence of many lower leaves. In mid-August, plants exhibited an extremely slow rate of young ramet production prior to flowering. Even under uncrowded conditions along the open-water side of the mat, plants produced very few ramets, and these were large and slow to develop. In late August and throughout September, most plants reached maturity and were >30 cm tall, ramet production slowed, and flowers were in full bloom. Maximum waterhyacinth biomass occurred in early to mid-September.

21. A general senescence of old, tall leaves in October produced openings in the waterhyacinth canopy that allowed for the formation of new, short leaves. As a consequence of this process, plant height ranged from 15 to 25 cm and biomass declined. Also, a second peak of ramet production (lower than in spring) was observed during this postblooming period.

22. Old leaves continued to senesce (and biomass declined) during November and December, and many plants, 15 to 20 cm in height, were present. The onset of cold weather triggered a general senescence of all plants in January, and a substantial reduction of biomass occurred by February.

Comparison of Biomass and Carbohydrates Among Plant Structures

Dry weight distribution

23. The proportions of dry weight allocated among plant structures varied monthly and are shown in Table 1. The highest proportion of plant weight was found in mature leaves and petioles during preblooming stages. For example, weights ranged from 18.2 to 27.8 percent for mature leaves and from 18.3 to 45.4 percent for mature petioles, from April to August 1988. However, when plants were in blooming or postblooming stages, roots often accounted for the highest proportion of plant weight. During these stages, root mass ranged from 23.0 percent in September 1987 to 38.8 percent of total plant weight in August 1987. Relationships between shoot and root mass and flowering are discussed later.

24. In October and November, many tall leaves were senescing or dead; therefore, a higher proportion of biomass was found in mature and old petioles. For example, in October 1987 and 1988, the old petiole proportion was 12.5 and 23.6 percent of total plant weight.

25. During December and January, most tall leaves were damaged or killed by frost, and many mature roots were senescing. Hence, a significant proportion of detrital material, composed of dead leaves, petioles, and roots, sloughed off and sank to the bottom of the tanks during these cold months. This was the period of maximum detritus production in the plant growth cycle.

26. In general, the dry weight proportion of leaves plus petioles was in the order mature > old > young. On the other hand, dry weight proportions of mature and old petioles were often greater than those of mature and old leaves, while the reverse occurred in young petioles and leaves. This higher proportion of mature and old petioles greatly contributes (along with the bulbous character of the petiole) to the vertical stability of the plant.

Carbohydrate concentrations

27. Generally, the highest concentrations of carbohydrates (particularly starch) were measured in mature leaves (Table 1). However, from July to November, the highest concentrations of carbohydrates were found in stem-bases. Stem-bases accumulated up to 20.8 percent free sugars, 31.4 percent TNC, and 11.7 percent starch by the September-October period.

28. After stem-bases, stolons contained the highest concentrations of free sugars and TNC from August to October. This period of high free sugars and TNC in stolons coincided with fall ramet production and indicates that stolons play a role in conducting free sugars from stem-bases to young ramets. Since stolons are the only connecting route between stem-bases and newly produced ramets, the enrichment of these structures with free sugars is reasonable. It is also possible that some stored carbohydrates in the stem-bases were mobilized to support the development of new ramets during late fall.

29. Typically, roots and young petioles had the lowest concentration of starch compared with other plant structures. Similarly, Penfound and Earle (1948) observed the least amount of starch in roots as compared with other structures of waterhyacinth.

30. Mature leaves, petioles, and stem-bases always contained significantly higher concentrations of carbohydrates than young leaves, petioles, and stem-bases, respectively. Since mature leaves and petioles are the most active photosynthetic organs, they should have higher levels of carbohydrates than young leaves and petioles. Likewise, since stem-bases are storage sites for food reserves, mature stem-bases should accumulate higher carbohydrate levels than young ones.

Seasonal Distribution of Dry Weight and Carbohydrates

Leaves, petioles, and membranes

31. Young leaves contributed 1.2 to 12.6 percent of total plant dry weight with the smallest proportions in September-October and the greatest proportions from April through July (Figure 4). Dry weight proportions of young petioles ranged from 1.3 to 5.9 percent (Figure 5) and followed trends similar to those of young leaves. These periods of high biomass in young structures reflected the period of active ramet production in the spring.

32. Mature leaves accounted for 5.8 to 27.7 percent of total weight, with greatest proportions occurring in the spring and early summer and smallest proportions occurring in the fall (Figure 6). The high biomass resulted from a waterhyacinth population that consisted of many medium- and large-sized plants with large leaves. In contrast, the smallest biomass, in the fall, was due to a high proportion of old and senescing leaves in the population. Distribution of biomass in mature petioles ranged from 9.5 to 45.3 percent

(Figure 7). Highest biomass occurred in midsummer due to elongation of the petiole in response to crowded growth conditions.

33. The weight of old leaves ranged from 1.7 to 8.8 percent, while old petioles ranged from 2.2 to 23.6 percent (Figures 8 and 9). Biomass of these two structures was greatest in October, when the population contained a higher proportion of old plants, and least in May, when many young plants were present. Seasonal biomass distribution of leaves and petioles in different age classes may indicate shifts in the growth stages of the waterhyacinth population.

34. Dry weight proportion of membranes was significantly greater in April (5.3 percent of total plant weight) and May (3.6 percent of total plant weight), when the waterhyacinth population consisted of many young plants (Figure 10). These diminutive plants had small proportions of other plant structures (e.g., leaves, petioles, stem-bases), resulting in a greater proportion of membranes. Although the mean proportion of membranes was small, compared with other plant parts, these structures play an important role in protecting young ramets. As new ramets emerge, they are wrapped entirely in a tubelike membrane filled with mucin, which acts as a protective envelope.

35. Seasonal patterns of carbohydrate allocation were found in mature leaves, as well as young and mature petioles (Figures 5-7). Young petioles contained significantly higher concentrations of carbohydrates in September and October than in other months. Spring petioles were generally smaller and less verdant than petioles produced in autumn. These factors may have contributed to the increased carbohydrate content found in young, fall petioles. Mature leaves and petioles had highest concentrations of carbohydrates around October. The high levels of carbohydrates in mature leaves and petioles during these cool months suggest that waterhyacinths were vigorously photosynthesizing to accumulate carbohydrates used for fall vegetative reproduction, and for food reserves in stem-bases.

36. No clear seasonal patterns of carbohydrate concentration were observed in young leaves and in old leaves and petioles (Figures 4, 8, and 9). No clear seasonal trends in starch concentrations were observed in membranes; however, levels of free sugars were significantly greater in membranes from August through November (Figure 10). This increase in free sugars was probably due to the high proportion of young membranes that were formed along with young, fall ramets.

Stem-bases and stolons

37. During February and March, the greatest proportion of total plant weight (15.8 and 17.6 percent, respectively) was found in surviving stem-bases (Figure 11). This large biomass proportion was due to frost-burn and death of many leaves and petioles over the winter. The proportion of dry weight allocated to stem-bases was small during other months.

38. Proportion of biomass allocated to stolons remained fairly constant through the seasons (Figure 12). The highest stolon weight, 5.5 percent in April 1988, corresponded to uncrowded growing conditions of early spring.

39. The concentration of carbohydrates in stem-bases ranged from 2.5 to 20.8 percent for free sugars, from 0.2 to 11.8 percent for starch, and from 3.4 to 31.5 percent for TNC (Figure 11). Carbohydrate levels in mature stem-bases were always greater than those in young stem-bases (Table 1). A trend of increasing carbohydrate levels in stem-bases was initiated in July-August and peaked in September-October. Early fall was the period when waterhyacinth stored maximum carbohydrate reserves in stem-bases for winter survival. The reduction of stem-base carbohydrate reserves which followed the October peak was the result of two factors: increasing amounts of necrotic tissue surrounding the stem-base/rhizome complex, and increasing abundance of young ramets in the population.

40. Results from TLC showed that starch and sucrose were the main components of stem-base carbohydrate reserves in winter. Fructose and glucose were also detected in stem-bases. The presence of sucrose, glucose, and fructose in stem-bases indicated that part of the starch reserves was being converted to simple sugars for the development of young tissues in response to warm fall days.

41. In the fall, even though stem-base proportion was less than 5 percent of total plant weight, the stem-bases contained up to 15 percent of free sugars, 20 percent of TNC, and 40 percent of starch found in the entire plant (calculated from data presented in Table 1).

42. The increase of free sugars and TNC in stolons was concurrent with the accumulation of carbohydrates in stem-bases during the fall. Though stolons contained lower starch levels compared with stem-bases, there was an increase of stolon starch from late summer to midfall (Figure 12). This trend implies that, in addition to stem-bases, stolons may play a role in the storage of carbohydrate reserves. Furthermore, stolons contained high levels of

free sugars in September-October, suggesting that stolons function as temporary storage sites, as well as conducting corridors for translocating sugars from mature stem-bases to developing ramets.

Roots

43. The proportion of biomass allocated to roots ranged from 8.1 to 38.8 percent (Figure 13). No seasonal patterns were noted in the proportion of biomass allocated to roots; however, this was clearly related to flowering and the availability of nutrients.

44. In flowering plants, root weight often exceeded 23 percent of total plant weight (shoot-to-root ratio <3.3), while in nonflowering plants root biomass was always less than 23 percent, yielding a shoot-to-root ratio >3.3 (Table 2). This root mass-flowering relationship is in agreement with our field observations. Blooming plants in Texas and Louisiana exhibited large, robust root systems, whereas plants in the vegetative stage had very short root systems.

45. Center and Spencer (1981) reported a shoot-to-root ratio for waterhyacinth from Lake Alice, Florida, that ranged from 2.0 to 2.5 from mid-March to mid-December. This ratio was much lower during winter months and declined to 0.2 in mid-February. Other investigators (Moorhead, Reddy, and Graetz 1988) showed that mean waterhyacinth shoot-to-root ratio was 1.93 (1.64 to 2.46) for plants grown in a fertilized reservoir and 1.14 (0.79 to 1.67) for plants grown in an unfertilized reservoir in central Florida. In general, shoot-to-root ratios reported from other studies were smaller than those reported in our study. The fact that these investigators included the stem-base/rhizome complex as part of the root mass may explain some of this discrepancy.

46. During June to mid-July 1988, we used 20-percent Hoagland solution to alleviate the deficient symptoms on plants. This high nutrient solution had a strong impact on the suppression of root growth, as shown in Figure 13. Plants displayed normal growth in 10-percent Hoagland solution; however, when grown in a 20-percent Hoagland solution, root growth was diminished relative to top growth (Figure 13). Similarly, Moorhead, Reddy, and Graetz (1988) found more root growth in an unfertilized reservoir than in a fertilized reservoir.

47. Also, the 20-percent Hoagland solution suppressed flowering during this time. In contrast, root growth was stimulated, roots became extremely

long, and flowers were abundant, when plants were grown in 5-percent Hoagland solution in adjacent culture tanks (personal observation). Root size apparently can be used as an indicator of flowering potential.

48. Root systems play an important role in the overall hormonal physiology of terrestrial plants, perhaps serve as centers for hormone synthesis, and distribute these hormones to various plant structures (Torrey 1976). Roots are major sites for cytokinin synthesis, and this hormone influences the partitioning of photoassimilates between shoots and roots (Gersani, Lips, and Sachs 1980). It is possible that roots play a similar role in waterhyacinth and that root mass is related to factors triggering the flowering process in this plant.

49. Root carbohydrate levels remained relatively constant on a seasonal basis. Concentrations averaged 4.0 percent for free sugars, 0.4 percent for starch, and 4.5 percent for TNC (Figure 13).

Inflorescences

50. Dry weight proportions of inflorescences ranged from 0.5 to 10.1 percent, while carbohydrate concentrations averaged 5.9 percent for free sugars, 0.9 percent for starch, and 7.0 percent for TNC (Table 3).

51. The decreased ability of waterhyacinth to produce ramets after flowering stimulated our interest in investigating the distribution of carbohydrates among inflorescence structures during and following blooming (Luu and Pesacreta 1988). Generally, inflorescence structures contained low levels of starch and high levels of free sugars. Starch concentration was highest (3.2 percent) in blooming rachises and lowest (0.5 percent) in old florets (Figure 14). Blooming rachises contained the highest average level of free sugars (22.8 percent) found in the inflorescence, as well as in the entire plant. These high levels of inflorescence free sugars indicate that blooming rachises are important carbohydrate sinks during the flowering process. The lowest concentrations of free sugars (8.6 percent) were found in old peduncles.

52. Free sugars and TNC decreased significantly in the rachises following inflorescence wilt (Figure 14); however, no change in carbohydrate levels occurred in peduncles over this same period. Carbohydrates may move from the rachis to the stem, via the peduncle, following flower wilt. This movement may act as an energy conservation mechanism, whereby the remaining

carbohydrates in the rachis are translocated toward other energy-demanding sinks (e.g., meristematic tissues of ramets or flowers).

General observations on young ramet production

53. The ratio of young leaves to mature leaves (YL/ML) was used to indicate periods of extensive production of young ramets. The YL/ML ratios of June and July 1987 and April through June 1988 (Table 2) were higher than any other periods of the study (except October 1987). These months represented an extensive period of young ramet production. A second phase of young ramet production occurred in October 1987 and November 1988, indicated by high YL/ML ratios. This new generation of young ramets occurred around the period when maximum food reserves were stored in the stem-bases. These data support the assumption that part of the food reserves was used to produce young ramets in late fall, and was translocated via stolons.

54. After an extensive period of biomass production and blooming in summer, there was a period in which the rate of young ramet production was extremely slow. This period occurred in late August or early September (1987 and 1988) and corresponded to the low YL/ML ratios of 0.30 (September 1987) and 0.10 (September 1988), as shown in Table 2.

55. The slow rate of young ramet production at this time was probably caused by one or more of the following: (a) crowded conditions; (b) plants produced larger stolons and ramets, hence requiring a longer time for young ramets to become fully developed; (c) plants began to store food reserves in the stem-bases; and (d) photosynthates were shunted toward flower bud formation, prior to the second peak of blooming. Most large (older) plants were accumulating food reserves, while most small (younger) plants were preparing for blooming during this period of slow ramet production.

Total nonstructural carbohydrates of whole plant

56. The TNC concentration of whole plants (Table 2) ranged from 3.4 to 9.6 percent ($\bar{x}$ = 6.0 percent). These results were similar to the mean whole-plant analysis of 7.8 percent reported for waterhyacinth growing near Orlando, FL (Boyd 1969). Tucker and DeBusk (1981) showed that lowest TNC (6.3 percent) occurred in midwinter, while highest TNC (8.8 percent) was in early summer in waterhyacinth from Fort Pierce, FL. In comparison, our studies showed that highest TNC occurred in late summer to early fall, with a maximum in October

of 9.6 percent and a minimum (3.4 percent) in early April. Since winter temperatures destroyed most of the waterhyacinth top growth, whole-plant analysis of TNC was not obtained for February and March. However, TNC of stem-bases during these months was 3.4 percent (Figure 11).

Simplified Pathways of Carbohydrate Mobilization in Waterhyacinth

57. The simplified pathways of carbohydrate mobilization in waterhyacinth are shown in Figure 15. These pathways were derived from well-established principles of plant physiology, as well as results from our research. Leaves and petioles are the principal sources* of carbohydrates in waterhyacinth during the growing season. The stem-bases are sinks during the growing season (particularly in the fall), since they receive and store carbohydrates translocated from leaves and petioles. However, during the winter and early spring, stem-bases act as sources, as their carbohydrates (stored in amyloplasts) are remobilized to support surviving meristems. Also, some of these carbohydrates are moved to newly activated meristems for leaf, stem, and root development.

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* The terms "source" and "sink" are often used in describing the mobilization of carbohydrates in plant systems. Carbohydrates always move from source to sink; hence, organs supplying or producing carbohydrates are sources, and the organs that receive and use carbohydrates are sinks.

PART III: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

58. This report documents seasonal changes in the distribution of biomass and concentration of carbohydrates in waterhyacinth, as well as comparisons of these parameters among plant parts. Conclusions from this work are as follows:

- a. The highest proportion of plant dry weight is found in mature leaves and petioles when plants are in the vegetative stage. However, when plants are flowering, roots account for the highest proportion of dry weight. Root size is apparently related to the onset of flowering.
- b. It is evident that stem-bases begin to accumulate carbohydrates in late summer, and these reserves reach a maximum in September or October.
- c. Stem-bases are the overwintering structures of the plant. They play an important role in the seasonal carbohydrate cycle of the plant by providing energy for dormant buds and new growth in the spring.
- d. Based on carbohydrate allocation, potential weak points in the growth cycle of waterhyacinth include the period shortly before mid-September to mid-October, when plants are actively translocating carbohydrates to stem-bases, and in early spring, when the weather is warm enough for young ramet emergence and carbohydrates in stem-bases are low.

Recommendations

59. The period of maximum carbohydrate reserves in stem-bases of waterhyacinth should be determined, under field conditions, to verify the results of this study. Since waterhyacinth occurs in latitudes ranging from central California to southern Florida, the effect of climate on cycling carbohydrates should also be evaluated.

60. Stimulation or suppression of flowering in waterhyacinth may be useful in management strategies. For example, flowering reduces the rate of young ramet production in waterhyacinth and is also related to ambient nutrient levels, root mass, and endogenous hormones. A basic understanding of the mechanisms driving the transition from vegetative to sexual reproductive stages (and vice versa) in waterhyacinth is lacking. Therefore, further

research is needed on the role of major plant hormones in waterhyacinth and their interaction with nutrients, roots, and flowering.

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Table 1

Concentrations of Carbohydrates (Free Sugars, Starch, TNC) and Distribution of Dry Weight Among Plant Parts (June 1987-January 1988 and April-November 1988)

Plant Part*	Parameter, percent - June 1987				Parameter, percent - July 1987			
	Free Sugars	Starch	TNC	Dry Weight	Free Sugars	Starch	TNC	Dry Weight
YL	3.6 [illegible]**	0.2 d	3.9 c	11.3 c	4.7 efg	2.1 a	7.1 d	12.6 bcd
YP	2.6 [illegible]	0.0 e	2.7 g	3.7 fg	4.1 g	0.4 de	4.7 f	5.9 efg
ML	4.6 a	0.3 bc	5.1 a	15.0 b	5.5 de	1.9 a	7.6 d	17.2 ab
MP	3.6 d	0.2 d	3.8 c	12.3 c	5.1 ef	0.7 cde	5.9 e	17.3 a
OL	4.5 a	0.5 a	5.1 a	5.0 ef	7.3 b	1.9 a	9.5 c	7.3 ef
OP	3.8 c	0.5 a	4.4 b	8.0 d	6.0 cd	0.9 cd	7.0 d	9.5 cde
SB	3.5 d	0.2 d	3.7 c	4.7 ef	11.6 a	1.0 bc	12.8 b	2.2 g
YR	3.1 e	0.0 e	3.2 ef	6.3 de	6.3 c	0.8 cd	7.3 d	8.7 de
MR	3.1 e	0.3 cd	3.5 d	28.7 a	4.9 efg	0.4 e	5.3 ef	13.6 abc
SL	2.7 f	0.2 cd	3.0 f	2.0 g	12.4 a	1.3 b	13.9 a	3.4 fg
MB	3.1 e	0.2 d	3.4 de	2.0 g	4.3 fg	0.5 de	4.9 ef	1.9 g
IN	4.1 b	0.4 ab	4.6 b	1.7 g	--	--	--	--
BLSD	0.2	0.1	0.2	2.0	0.7	0.4	1.0	4.6

Plant Part*	Parameter, percent - August 1987				Parameter, percent - September 1987			
	Free Sugars	Starch	TNC	Dry Weight	Free Sugars	Starch	TNC	Dry Weight
YL	6.1 d	1.6 a	7.9 c	4.9 d	3.7 g	1.3 def	5.2 de	5.5 d
YP	4.6 ef	0.6 cde	5.3 d	5.5 d	5.1 efg	1.4 cde	6.7 d	4.1 e
ML	6.1 d	1.6 a	8.0 c	9.1 b	5.9 de	4.2 a	10.6 c	18.3 b
MP	4.9 ef	0.9 bc	5.9 d	9.9 b	7.4 cd	1.8 bc	9.4 c	22.6 a
OL	4.4 f	0.8 cde	5.3 d	5.9 cd	4.9 efg	0.9 fgh	6.0 de	3.6 ef
OP	4.8 ef	0.4 e	5.3 d	9.4 b	5.5 ef	0.8 gh	6.4 de	7.2 c
SB	11.0 a	1.3 ab	12.5 a	2.5 e	--	--	--	--
YS	--	--	--	--	11.1 b	1.1 efg	12.3 b	1.6 g
MS	--	--	--	--	17.1 a	2.0 b	19.4 a	3.6 ef
RT	5.1 e	0.4 e	5.5 d	38.8 a	4.1 fg	0.6 h	4.9 e	23.0 a
SL	9.2 b	0.9 bcd	10.2 b	3.6 de	8.1 c	0.9 fgh	9.2 c	3.9 ef
MB	5.0 ef	0.5 de	5.6 d	2.5 e	4.8 efg	0.7 gh	5.7 de	2.6 fg
IN	7.0 c	1.3 ab	8.5 c	7.9 bc	8.6 c	1.6 bcd	10.4 c	3.9 ef
BLSD	0.6	0.4	0.9	2.3	1.5	0.4	1.7	1.2

(Continued)

* Young leaf (YL), young petiole (YP), mature leaf (ML), mature petiole (MP), old leaf (OL), old petiole (OP), stem-base (SB), young root (YR), mature root (MR), young stem-base (YS), mature stem-base (MS), root (RT), stolon (SL), membrane (MB), inflorescence (IN).

** Means within a column followed by the same letter are not statistically different at 5-percent level, according to Bayesian Least Significant Difference (BLSD) test.

Table 1 (Continued)

Plant Part	Parameter, percent - October 1987 Free Sugars	Starch	TNC	Dry Weight	Parameter, percent - November 1987 Free Sugars	Starch	TNC	Dry Weight
YL	4.8 e	1.9 cd	6.9 ef	6.3 d	5.9 de	1.4 bc	7.5 bc	3.8 efg
YP	5.0 e	1.0 cd	6.2 ef	4.5 def	4.8 efg	0.4 fgh	5.3 d	2.5 ghi
ML	5.9 e	3.8 bc	10.1 d	11.4 c	8.9 bc	2.6 a	11.8 a	15.6 c
MP	8.3 c	5.0 ab	13.9 b	15.7 b	6.1 d	1.5 b	7.9 bc	18.6 b
OL	6.0 de	3.4 bcd	9.8 d	6.3 de	5.8 def	1.1 bcd	7.1 c	4.7 e
OP	7.9 c	2.5 bcd	10.7 cd	12.5 c	6.0 d	1.2 bcd	7.3 c	9.7 d
YS	7.5 cd	1.1 cd	8.8 de	1.4 h	7.9 c	0.8 def	8.8 b	1.6 i
MS	18.7 a	6.6 a	26.1 a	3.8 fg	10.8 a	1.0 cde	11.9 a	2.9 fghi
RT	4.5 e	0.7 d	5.3 f	27.8 a	4.2 g	0.2 h	4.5 d	31.4 a
SL	11.5 b	1.6 cd	13.3 bc	4.5 ef	9.6 ab	0.7 defg	10.5 a	4.0 ef
MB	5.0 e	0.8 d	5.9 f	2.5 gh	4.6 fg	0.2 gh	4.9 d	2.3 hi
IN	7.6 c	2.2 cd	10.0 d	3.2 efg	6.3 d	0.5 efgh	6.9 c	3.0 fgh
BLSD	1.5	2.7	2.8	1.7	1.1	0.5	1.4	1.3

Plant Part	Parameter, percent - December 1987 Free Sugars	Starch	TNC	Dry Weight	Parameter, percent - January 1988 Free Sugars	Starch	TNC	Dry Weight
YL	4.3 cdef	1.0 c	5.4 cd	4.2 e	2.7 c	0.7 cde	3.6 d	3.3 d
YP	2.4 h	0.3 e	2.7 h	2.4 fg	2.0 d	0.9 abcde	3.0 e	2.2 d
ML	7.2 a	1.8 a	9.3 a	19.8 c	3.4 ab	1.1 a	4.7 ab	15.3 c
MP	4.8 bcd	0.8 cd	5.7 bcd	23.7 b	2.9 bc	0.9 abcde	3.9 cd	34.8 a
OL	4.9 bc	1.5 b	6.5 b	2.3 fg	3.7 a	1.1 a	5.0 a	3.2 d
OP	4.1 defg	0.8 cd	5.0 def	7.6 d	3.5 a	0.9 abcd	4.6 ab	5.4 d
YS	3.7 fg	0.4 de	4.2 fg	1.6 g	2.8 c	0.7 e	3.6 d	1.0 d
MS	5.3 b	0.6 cde	6.1 bc	2.5 fg	3.0 bc	0.7 de	3.8 cd	3.7 d
RT	4.0 efg	0.3 e	4.3 efg	30.0 a	3.6 a	1.0 abc	4.8 a	26.9 b
SL	3.4 g	0.4 e	3.8 g	3.1 ef	2.8 c	0.8 bcde	3.8 cd	2.4 d
MB	3.5 g	0.4 e	4.0 g	1.6 g	3.3 ab	0.8 bcde	4.2 bc	1.3 d
IN	4.6 cde	0.4 de	5.1 de	1.2 g	3.4 ab	1.0 ab	4.6 ab	0.5 d
BLSD	0.7	0.3	0.8	1.4	0.4	0.2	0.5	6.3

(Continued)

Table 1 (Continued)

Plant Part	Parameter, percent - April 1988: Free Sugars	Starch	TNC	Dry Weight	Parameter, percent - May 1988: Free Sugars	Starch	TNC	Dry Weight
YL	2.5 e	0.3	2.8 de	10.6 c	2.5 d	0.2 d	2.8 f	11.4 d
YP	1.8 f	0.4	2.4 e	5.4 d	1.9 e	0.3 cd	2.3 g	3.8 e
ML	3.6 ab	0.3	4.1 ab	22.1 a	4.7 a	0.7 a	5.5 a	27.8 a
MP	3.0 cd	0.2	3.3 cd	18.3 b	3.2 b	0.4 cd	3.7 cde	22.3 b
OL	3.4 bc	0.2	3.6 bc	3.8 e	4.5 a	0.7 ab	5.3 a	1.7 f
OP	2.8 de	0.4	3.4 cd	5.3 d	3.2 b	0.5 abcd	3.8 bcd	2.2 f
SB	3.0 cd	0.3	3.4 cd	5.4 d	3.4 b	0.5 abc	4.1 b	3.6 e
RT	2.8 de	0.2	3.1 cd	17.8 b	3.5 b	0.4 abcd	4.0 bc	18.9 c
SL	3.8 a	0.3	4.2 a	5.5 d	2.8 cd	0.4 bcd	3.3 e	4.3 e
MB	2.8 de	0.3	3.2 cd	5.4 d	2.8 c	0.5 abcd	3.4 de	3.6 e
BLSD	0.3	NS	0.5	0.8	0.2	0.2	0.4	0.9
	Parameter, percent - June 1988: Free Sugars	**Starch**	**TNC**	**Dry Weight**	**Parameter, percent - July 1988: Free Sugars**	**Starch**	**TNC**	**Dry Weight**
YL	2.3 e	0.4	2.8 e	10.5 c	3.1 ef	0.3	3.5 f	6.5 cd
YP	2.4 e	0.3	2.8 e	5.1 d	2.6 f	0.4	3.1 f	3.8 cde
ML	3.9 b	0.7	4.8 ab	26.3 a	5.4 b	0.6	6.1 b	21.9 b
MP	3.4 c	0.5	4.0 c	27.0 a	4.1 cd	0.7	4.9 cde	45.4 a
OL	4.4 a	0.7	5.3 a	3.4 e	5.1 b	0.8	6.0 b	2.3 de
OP	3.4 c	0.4	4.0 cd	4.2 de	4.1 cd	0.8	5.1 bcd	4.0 cde
SB	4.2 ab	0.5	4.9 ab	3.7 de	6.6 a	0.8	7.5 a	4.0 cde
RT	3.1 cd	0.3	3.5 d	12.1 b	3.3 def	0.4	3.9 ef	8.1 c
SL	4.3 a	0.4	4.8 ab	4.2 de	4.8 bc	0.5	5.5 bc	1.2 e
MB	2.9 d	0.7	3.7 cd	2.8 e	3.5 de	0.4	4.0 def	2.5 de
BLSD	0.3	NS	0.4	1.4	0.8	NS	1.0	4.4

(Continued)

Table 1 (Concluded)

Plant Part	Parameter, percent - August 1988				Parameter, percent - September 1988			
	Free Sugars	Starch	TNC	Dry Weight	Free Sugars	Starch	TNC	Dry Weight
YL	4.6 d	0.3 de	5.1 d	6.3 d	5.7 de	1.8 bc	7.8 c	1.2 g
YP	3.9 d	0.3 de	4.2 d	4.3 ef	5.7 de	1.7 bc	7.6 c	1.3 g
ML	5.8 c	0.7 c	6.6 c	18.2 b	6.6 cd	1.7 bc	8.5 c	11.5 c
MP	6.7 c	0.5 cd	7.3 c	30.0 a	6.8 cd	2.1 b	9.1 c	21.5 b
OL	4.5 d	0.4 cde	5.0 d	3.5 ef	4.5 e	0.8 de	5.4 d	4.5 e
OP	4.0 d	0.5 cd	4.6 d	8.7 c	5.1 e	0.4 e	5.5 d	10.9 c
SB	12.2 a	1.7 a	14.1 a	4.9 de	20.8 a	9.5 a	31.4 a	4.8 e
RT	4.1 d	0.3 de	4.5 d	17.3 b	4.7 e	0.2 e	4.9 d	28.0 a
SL	10.2 b	1.0 b	11.3 b	3.9 ef	13.5 b	1.1 cd	14.8 b	4.0 ef
MB	4.1 d	0.2 e	4.4 d	3.0 f	4.6 e	0.4 e	5.1 d	3.1 f
IN	--	--	--	--	7.3 c	0.9 de	8.3 c	8.8 d
BLSD	1.1	0.3	1.2	1.7	1.3	0.7	1.7	1.1

Plant Part	Parameter, percent - October 1988				Parameter, percent - November 1988			
	Free Sugars	Starch	TNC	Dry Weight	Free Sugars	Starch	TNC	Dry Weight
YL	6.3 de	0.6 bc	7.0 cd	1.2 f	3.2 fg	0.3 bc	3.6 ef	2.9 g
YP	5.9 efg	1.0 bc	7.0 cd	1.4 f	2.8 g	0.2 c	3.1 f	2.7 g
ML	7.8 c	2.3 bc	10.4 c	5.8 d	6.1 b	0.4 bc	6.6 bc	7.6 e
MP	7.5 cd	2.8 bc	10.7 c	9.5 c	5.5 b	1.6 b	7.4 b	13.4 c
OL	4.8 fgh	0.2 c	5.0 d	8.8 c	3.5 efg	0.7 bc	4.3 def	5.3 f
OP	4.2 h	0.3 bc	4.6 d	23.6 b	3.7 def	0.9 bc	4.8 de	16.0 b
SB	16.1 a	11.7 a	29.2 a	5.0 de	8.5 a	9.8 a	19.4 a	4.9 f
RT	4.6 gh	0.1 c	4.8 d	31.7 a	4.5 c	0.3 bc	4.9 de	31.5 a
SL	12.7 b	5.0 b	18.3 b	2.2 f	4.4 cd	1.0 bc	5.6 cd	2.0 g
MB	5.0 efgh	0.1 c	5.2 d	2.6 ef	4.3 cd	0.5 bc	4.9 de	3.0 g
IN	6.0 ef	0.5 bc	6.6 cd	7.6 cd	4.1 cde	0.6 bc	4.9 de	10.1 d
BLSD	1.3	4.7	4.8	2.8	0.7	1.3	1.6	1.7

Table 2

Whole Plant TNC, Young Leaves/Mature Leaves Ratio (YL/ML), Shoot-to-Root Ratio (ST/RT), Root Percentage, and Existence of Inflorescence in Plant Samples (Data Generated from Table 1, Based on Dry Weight)

Date	TNC* percent	YL/ML	ST/RT**	Root Percentage	Inflorescence
June 1987	3.9	0.7	1.8	35.0	Yes (W)†
July 1987	7.1	0.7	3.5	22.3	No
August 1987	6.4	0.5	1.6	38.8	Yes (F+W)
September 1987	8.2	0.3	3.3	23.0	Yes (F)
October 1987	9.6	0.5	2.6	27.8	Yes (W)
November 1987	7.4	0.2	2.2	31.4	Yes (W)
December 1987	5.8	0.2	2.3	30.0	Yes (W)
January 1988	4.3	0.2	2.7	26.9	Yes (W)
April 1988	3.4	0.5	4.6	17.8	No
May 1988	4.1	0.4	4.3	18.9	No
June 1988	4.1	0.4	7.3	12.1	No
July 1988	5.0	0.3	11.3	8.1	No
August 1988	6.5	0.3	4.8	17.3	No
September 1988	8.4	0.1	2.6	28.0	Yes (F)
October 1988	7.4	0.2	2.1	31.7	Yes (F+W)
November 1988	5.9	0.4	2.2	31.5	Yes (W)

* Total nonstructural carbohydrates of whole plant.

** Shoot consisted of all plant structures except roots.

† "Yes" or "No" indicates the presence or absence of inflorescence in the samples. F is flowering inflorescence; W is wilted inflorescence.

Table 3

Concentrations of Carbohydrates and Distribution of Dry Weight in Inflorescences for Different Months

Date	Parameter, percent			
	Free Sugars	Starch	TNC	Dry Weight
June 1987	4.1 ef*	0.4 d	4.6 g	1.6 de
August 1987	7.0 bc	1.3 bc	8.5 bc	7.8 b
September 1987	8.6 a	1.6 ab	10.4 a	3.9 c
October 1987	7.6 b	2.2 a	10.0 ab	3.1 c
November 1987	6.3 cd	0.5 cd	6.9 de	3.0 cd
December 1987	4.6 e	0.4 d	5.1 fg	1.2 e
January 1988	3.4 f	1.0 bcd	4.6 g	0.5 e
September 1988	7.3 b	0.9 bcd	8.3 cd	8.8 ab
October 1988	6.0 d	0.5 cd	6.6 ef	7.6 b
November 1988	4.1 ef	0.6 cd	4.9 g	10.1 a
BLSD	0.9	0.7	1.5	1.3
Mean**	5.9	0.9	7.0	4.8

* Means within a column followed by the same letter are not statistically different at 5-percent level, according to BLSD test.

** Mean averaged over all dates.

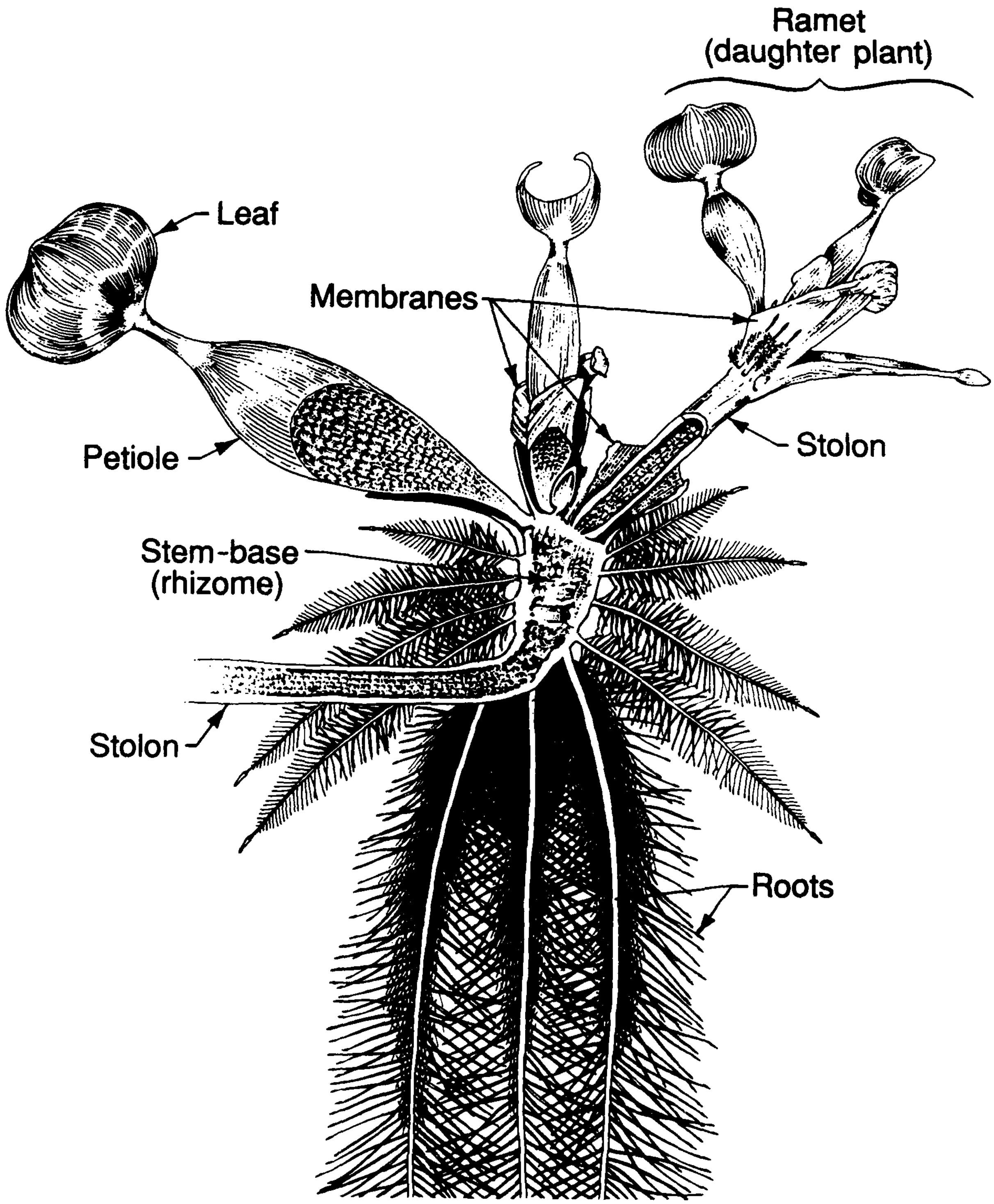

Figure 1. Major vegetative structures of waterhyacinth

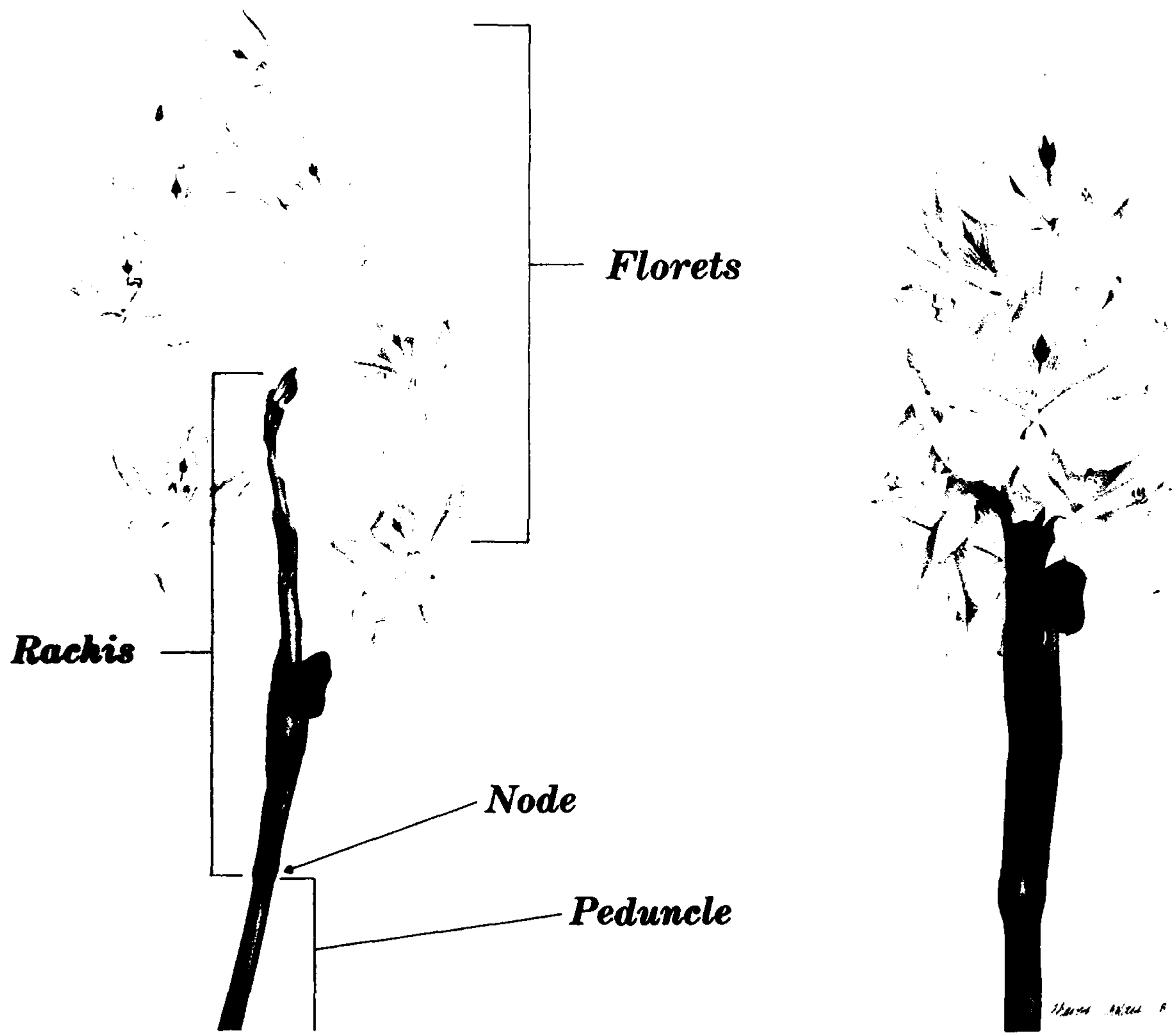

Figure 2. Major structures of waterhyacinth inflorescence

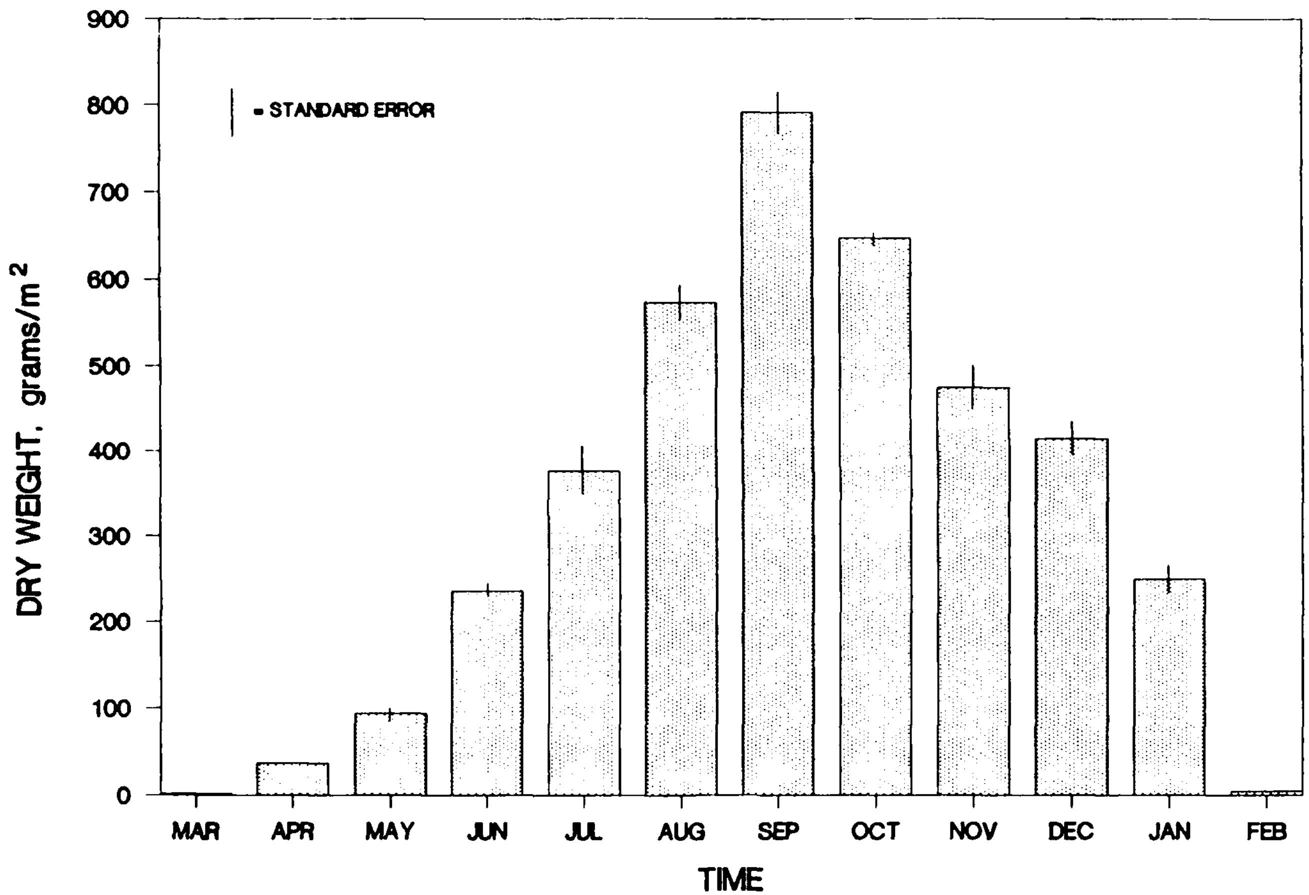

Figure 3. Mean dry weight mass of waterhyacinth on a seasonal basis

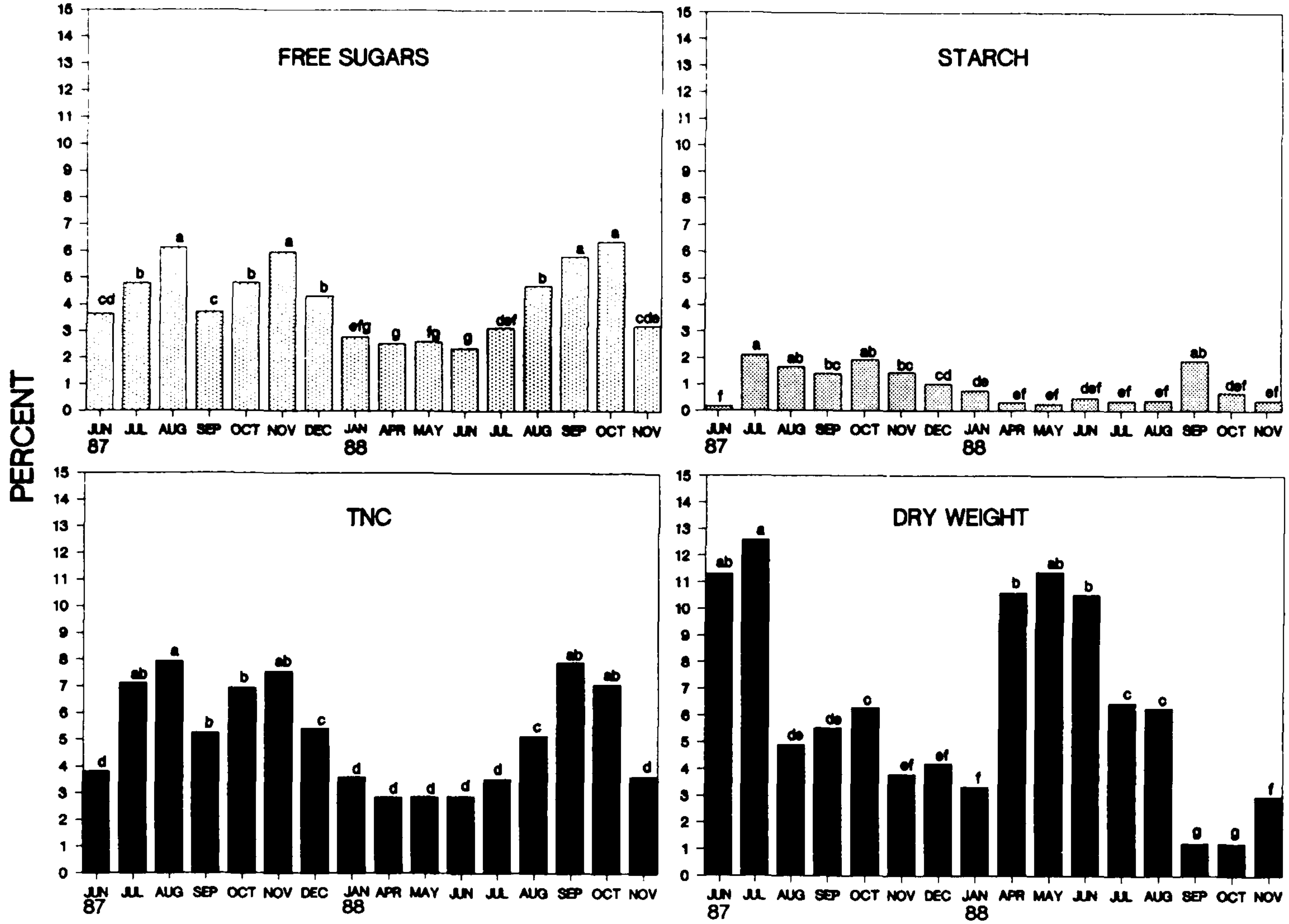

Figure 4. Seasonal distribution of free sugars, starch, TNC, and dry weight in young leaves. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

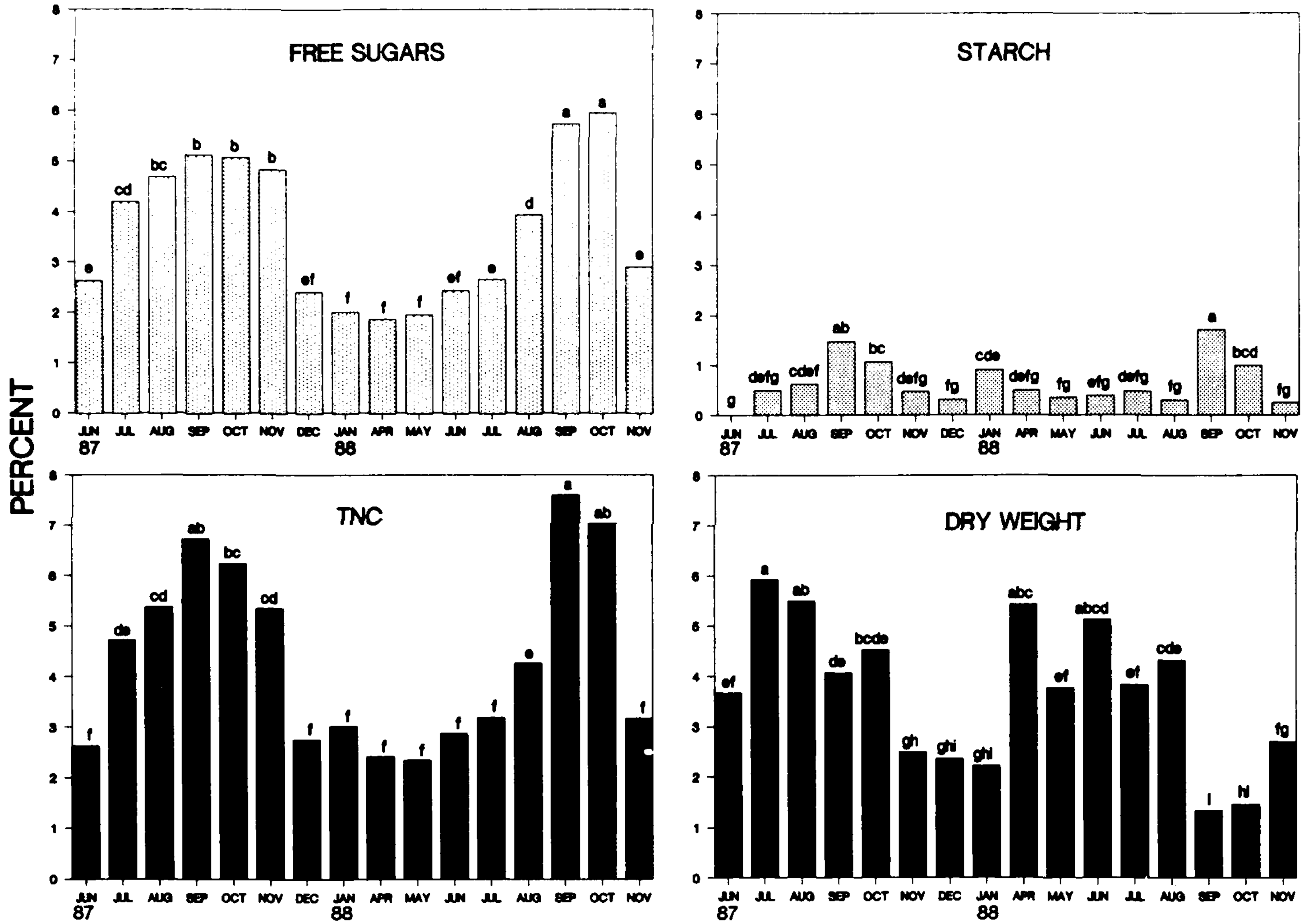

Figure 5. Seasonal distribution of free sugars, starch, TNC, and dry weight in young petioles. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

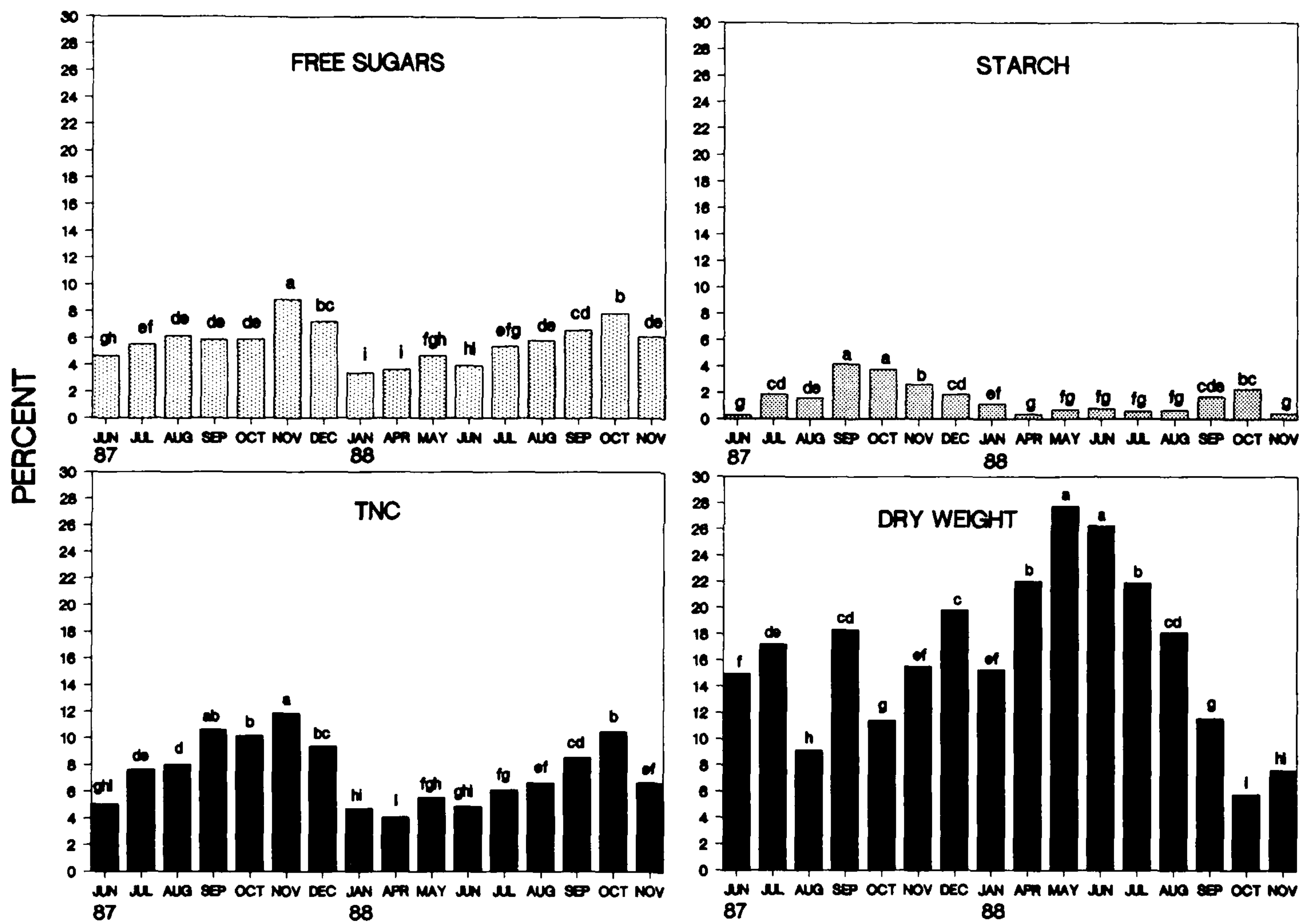

Figure 6. Seasonal distribution of free sugars, starch, TNC, and dry weight in mature leaves. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

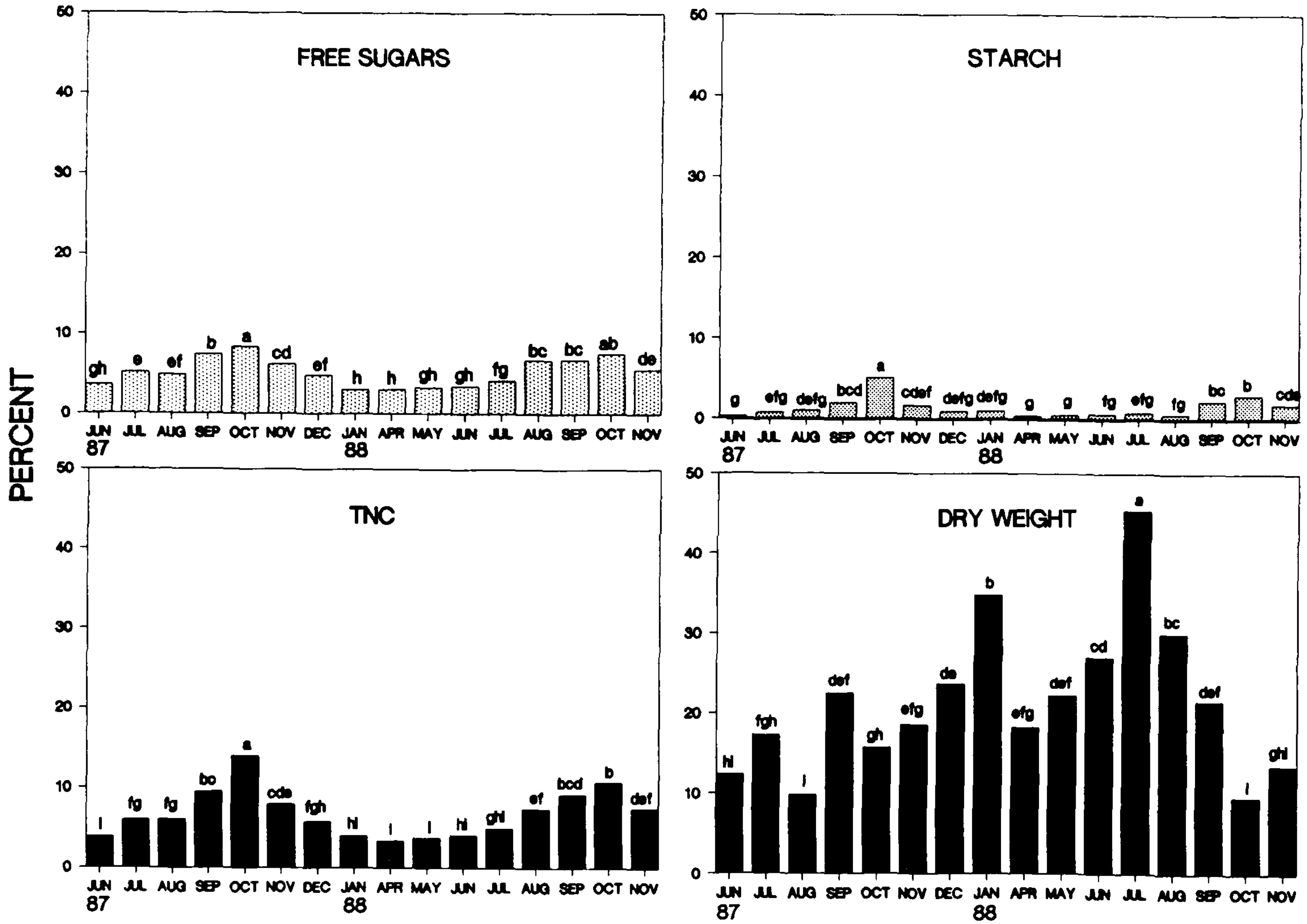

Figure 7. Seasonal distribution of free sugars, starch, TNC, and dry weight in mature petioles. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

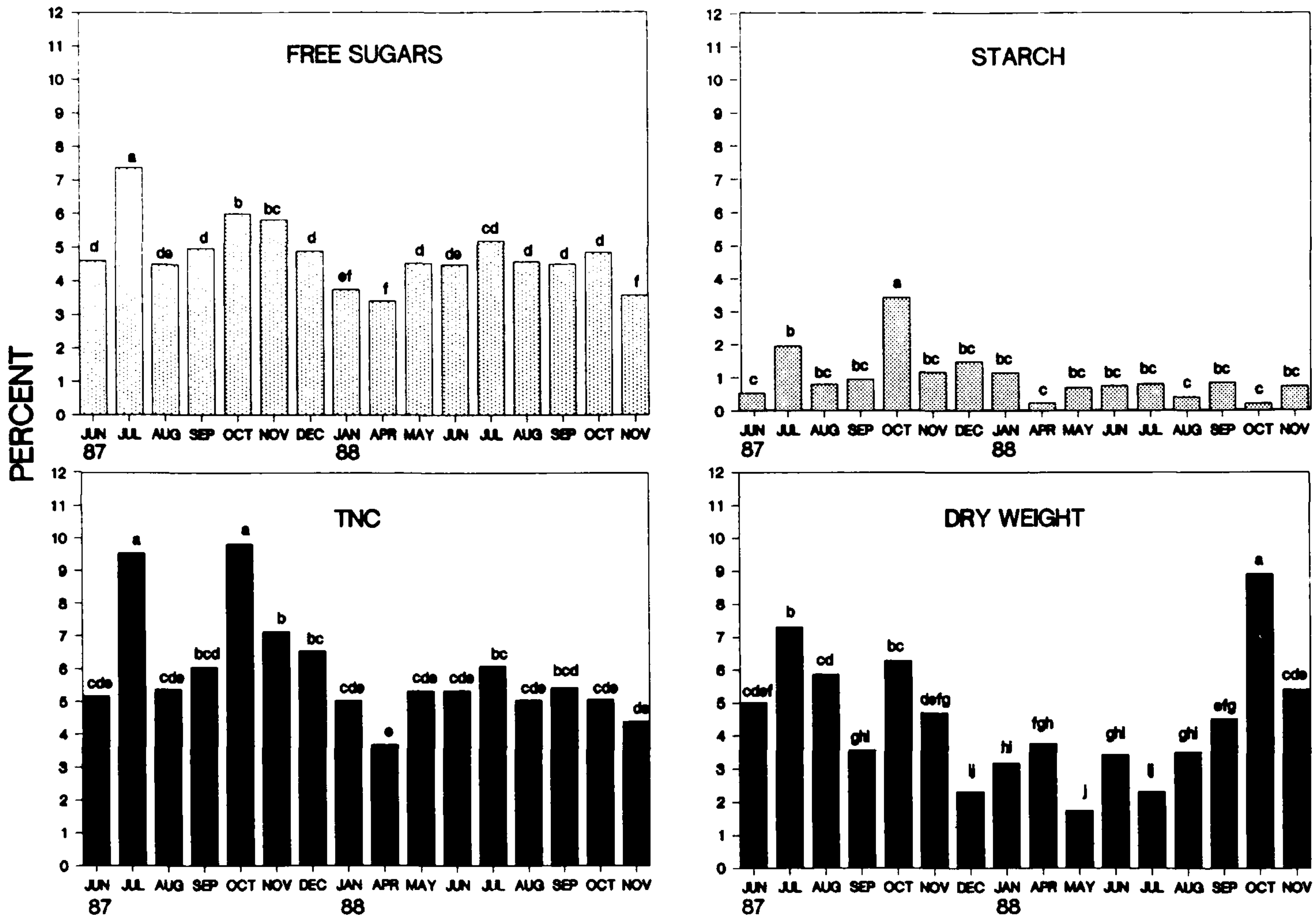

Figure 8. Seasonal distribution of free sugars, starch, TNC, and dry weight in old leaves. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

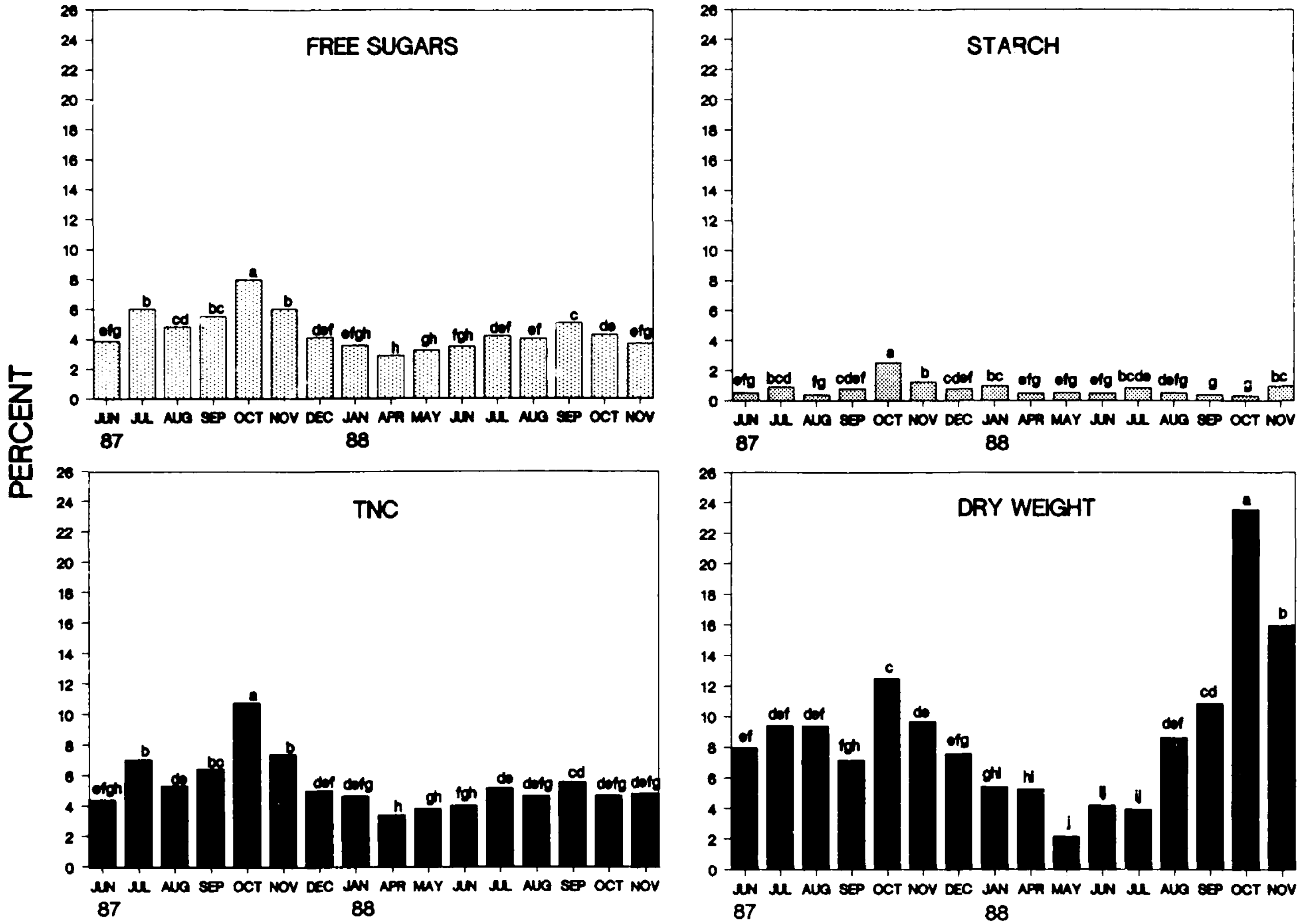

Figure 9. Seasonal distribution of free sugars, starch, TNC, and dry weight in old petioles. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

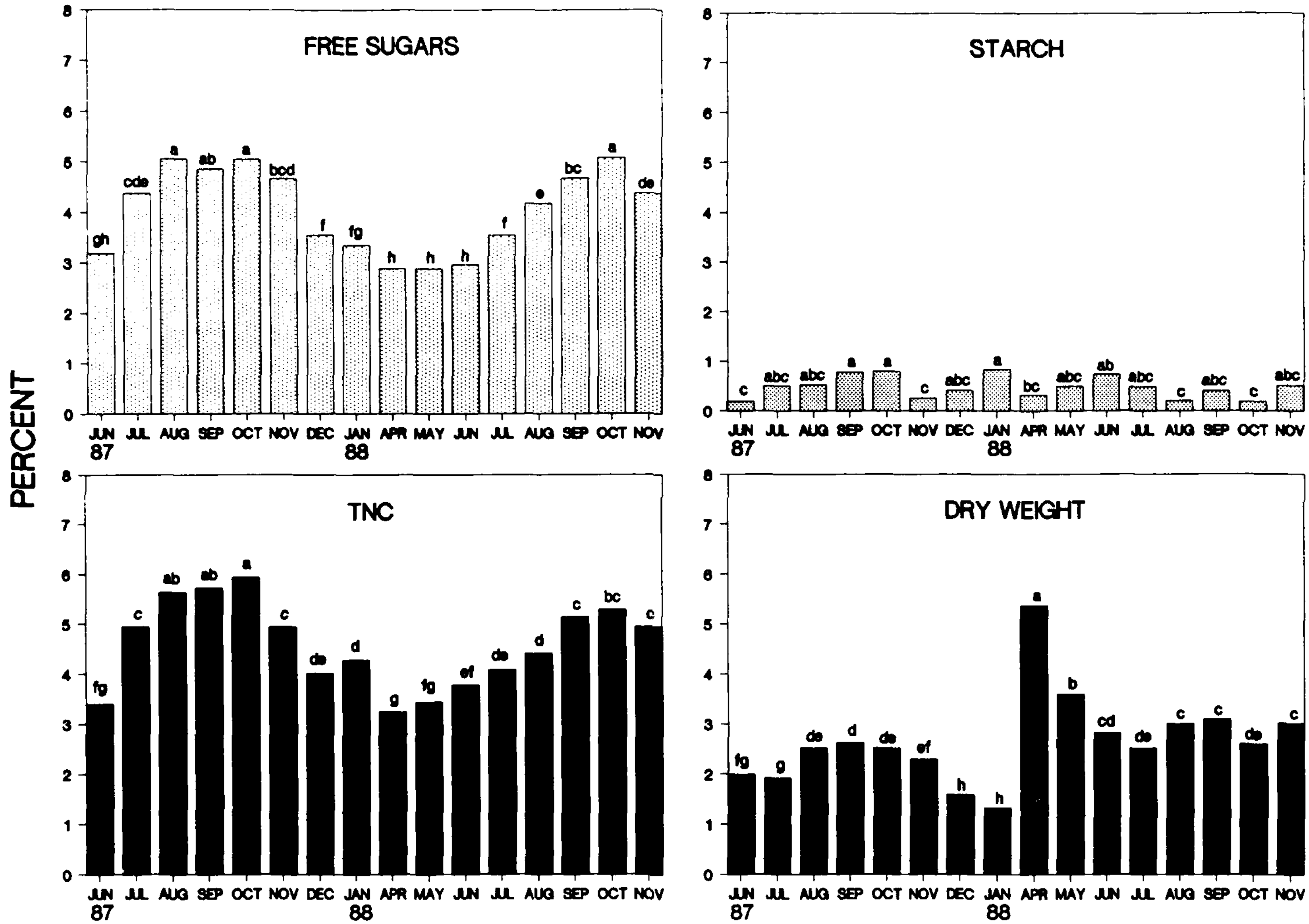

Figure 10. Seasonal distribution of free sugars, starch, TNC, and dry weight in membranes. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

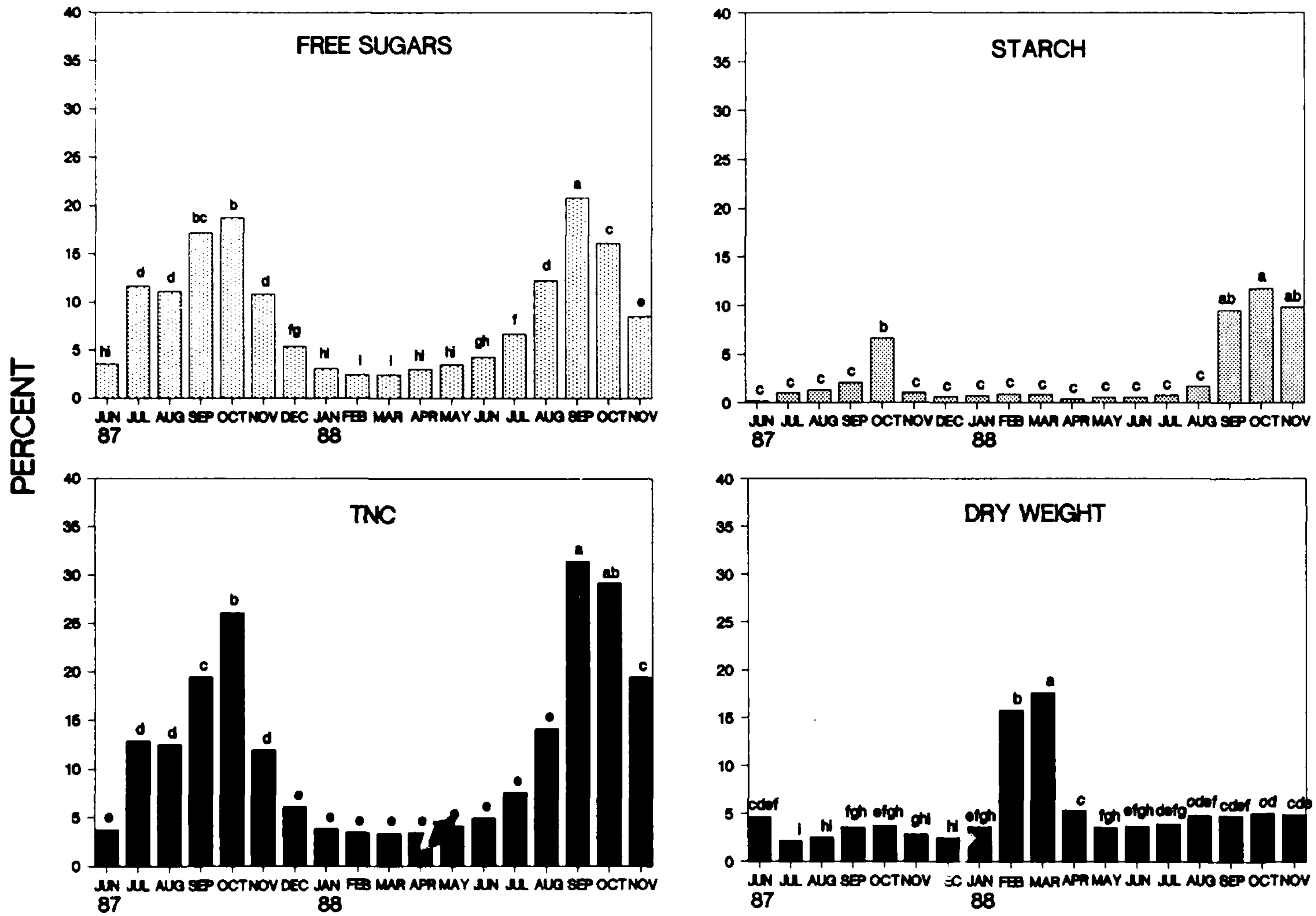

Figure 11. Seasonal distribution of free sugars, starch, TNC, and dry weight in stem-bases. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

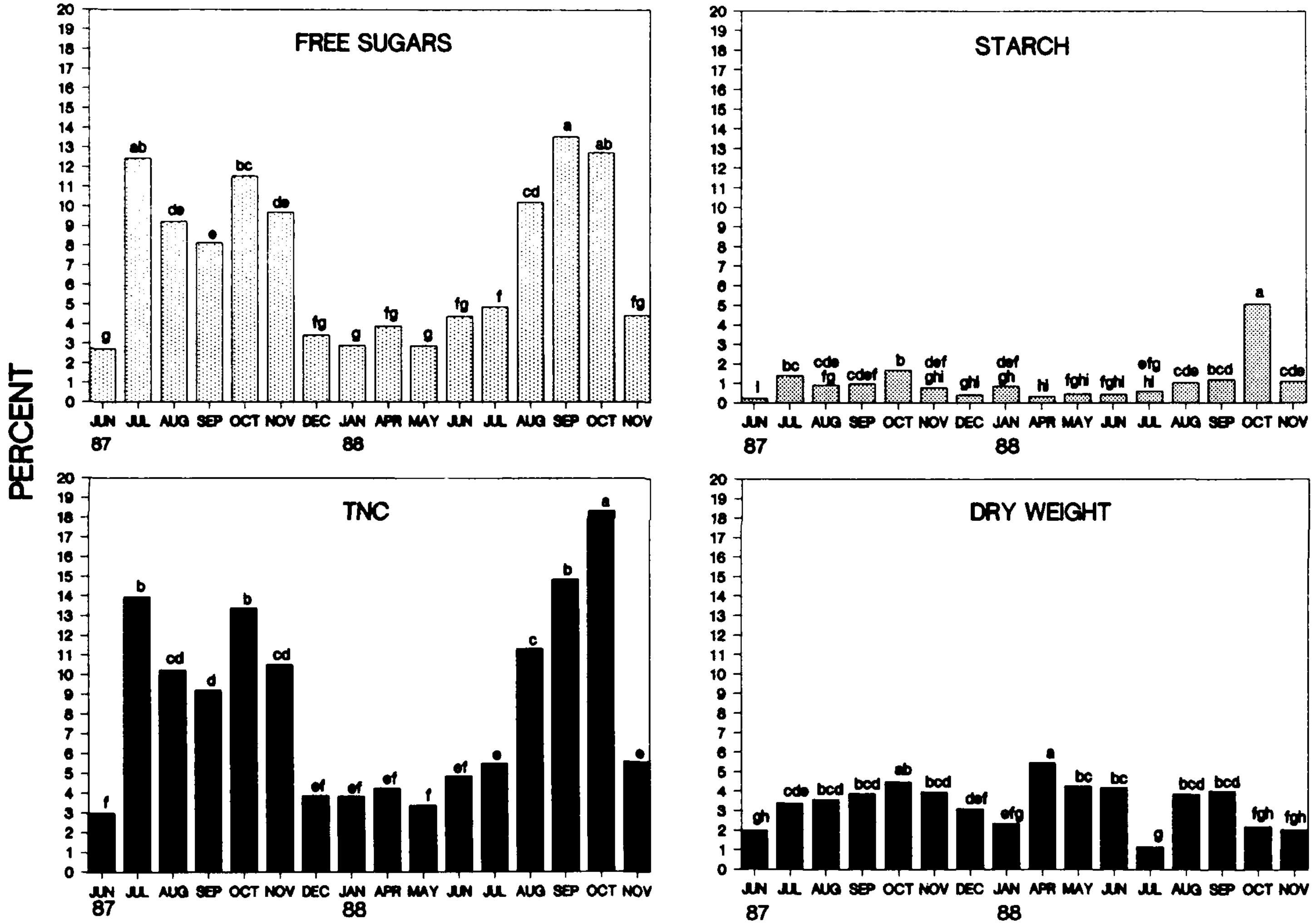

Figure 12. Seasonal distribution of free sugars, starch, TNC, and dry weight in stolons. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

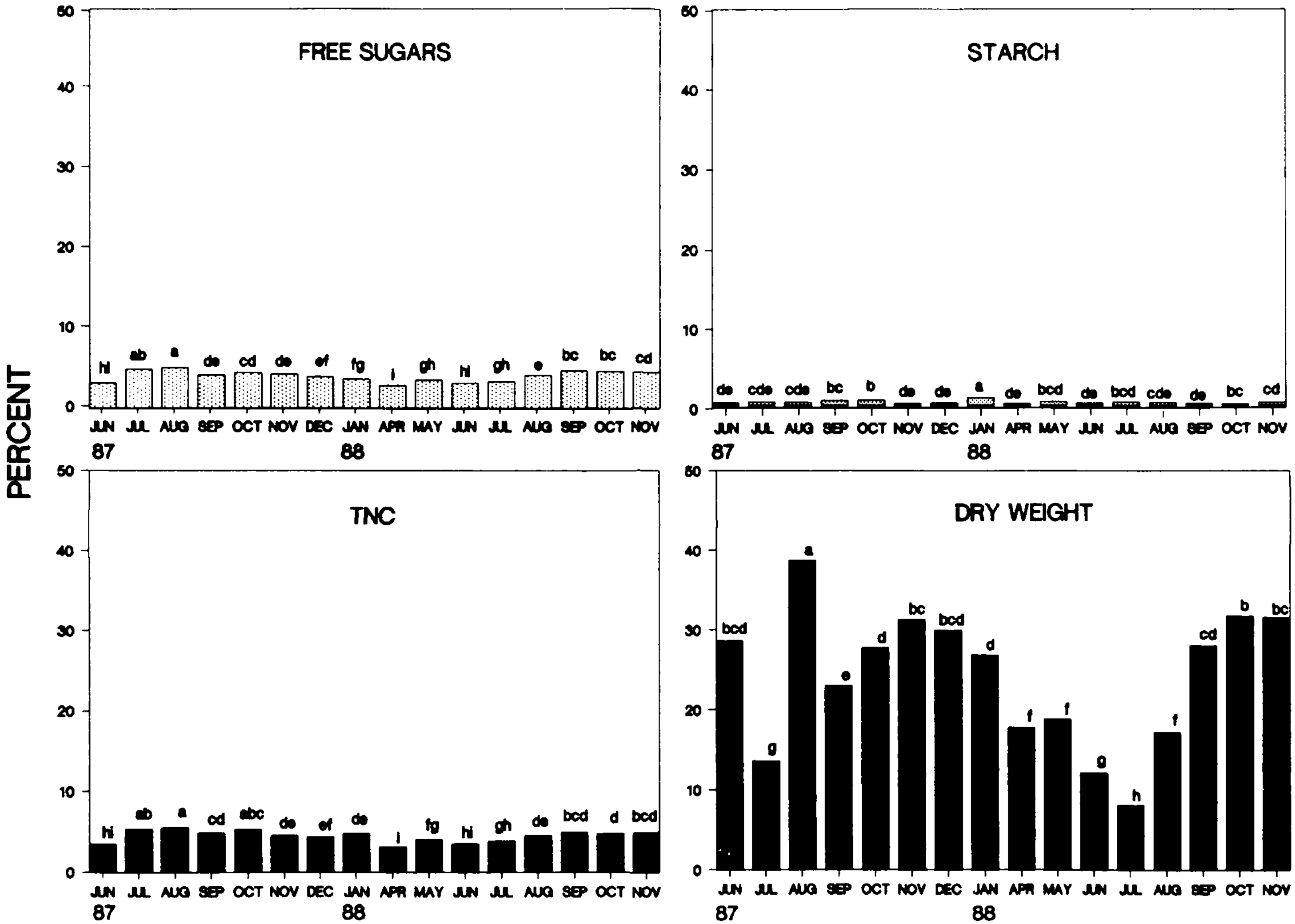

Figure 13. Seasonal distribution of free sugars, starch, TNC, and dry weight in roots. Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

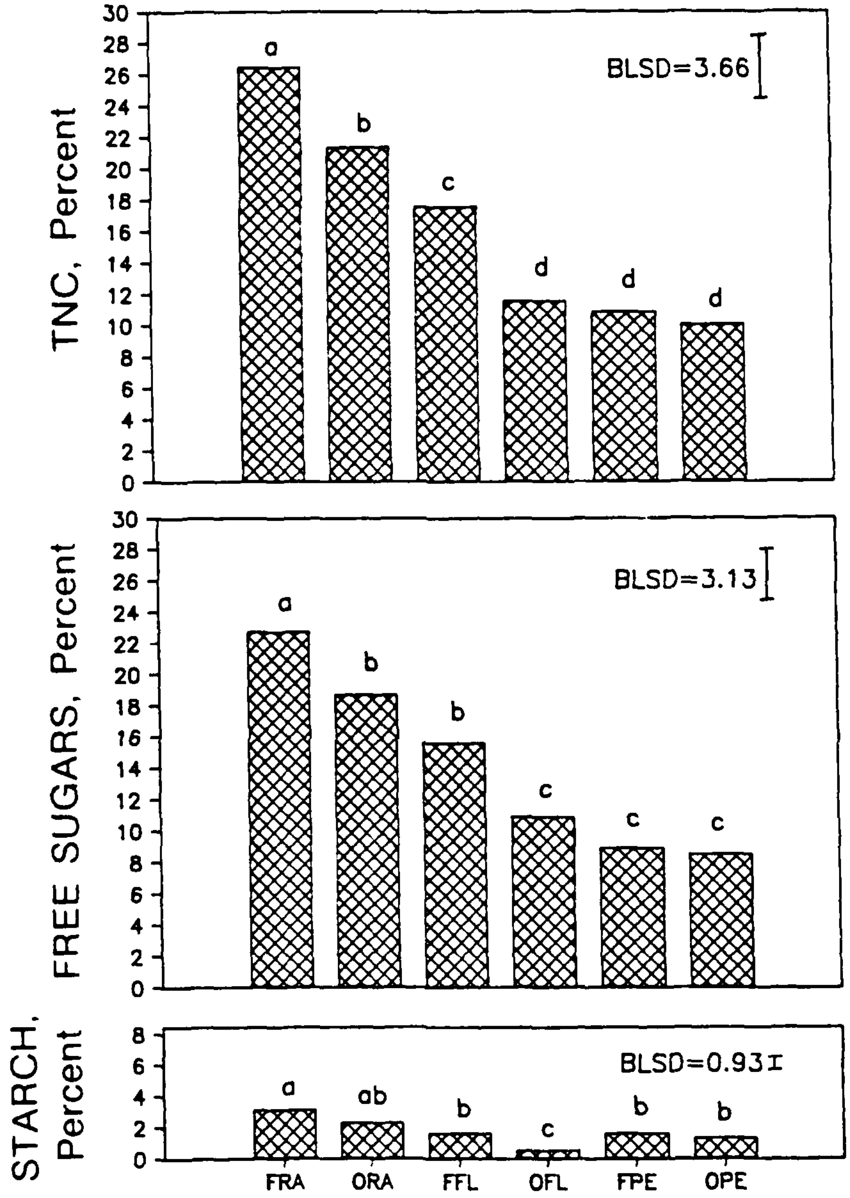

Figure 14. Carbohydrate distribution in various inflorescence structures. Flowering rachis (FRA), old rachis (ORA), flowering floret (FFL), old floret (OFL), flowering peduncle (FPE), and old peduncle (OPE). Different letters within a subfigure indicate significant differences at the 5-percent level according to BLSD test

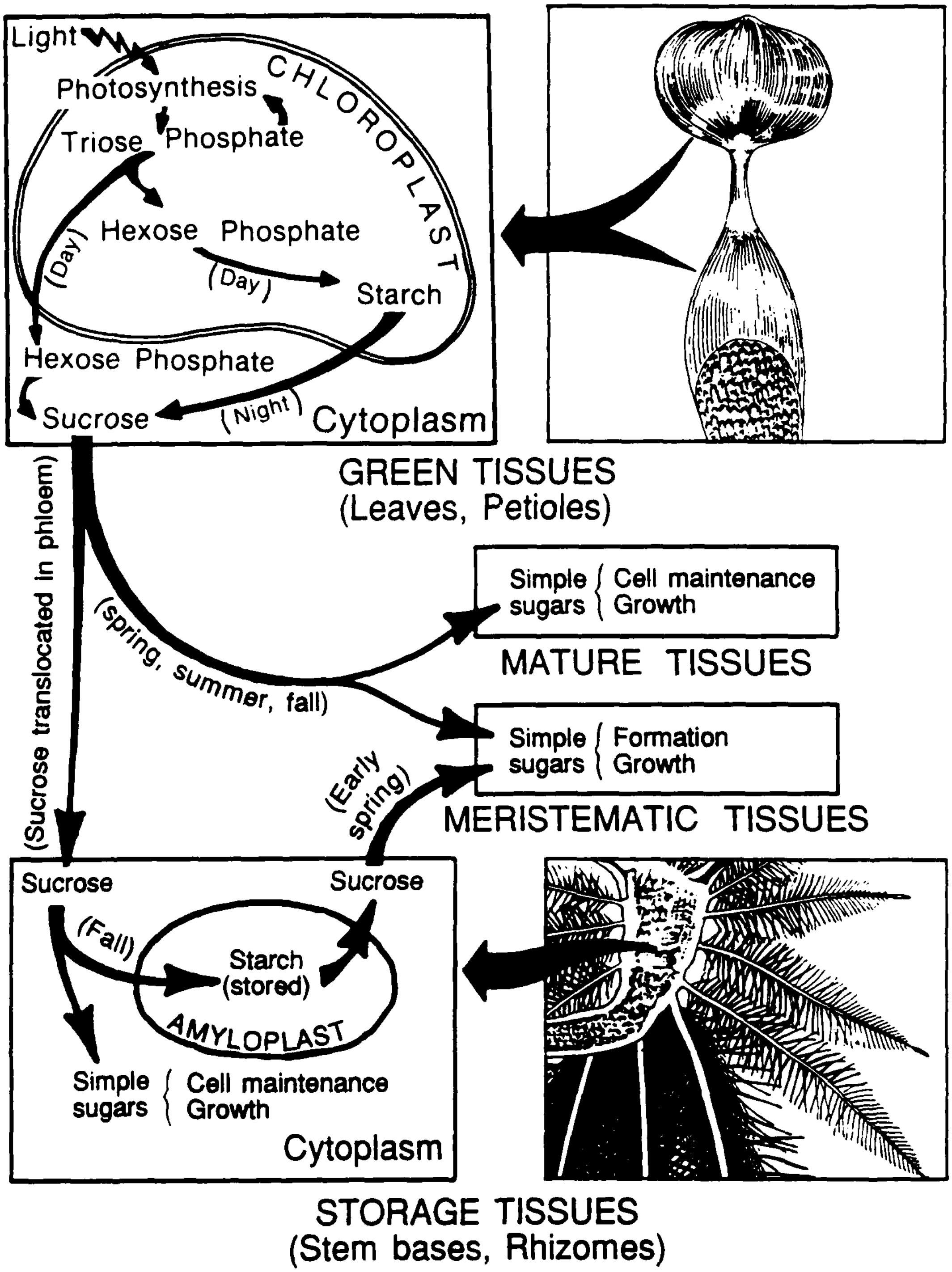

Figure 15. Simplified pathway of carbohydrate movement in waterhyacinth

APPENDIX A: DRY WEIGHTS AND CARBOHYDRATE CONCENTRATIONS: MEANS, STANDARD DEVIATIONS, AND STANDARD ERRORS

Key

Symbol	Explanation
OBS	Observation
PART	Plant parts (see Table 1 of the main text)
N	Replicates
MPFREE	Mean of percent free sugars
MPTOT	Mean of percent TNC
MPSTAR	Mean of percent starch
MPDW	Mean of percent dry weight
SDPFREE	Standard deviation for percent free sugars
SDPTOT	Standard deviation for percent TNC
SDPSTAR	Standard deviation for percent starch
SDPDW	Standard deviation for percent dry weight
SEPFREE	Standard error for percent free sugars
SEPTOT	Standard error for percent TNC
SEPSTAR	Standard error for percent starch
SEPDW	Standard error for percent dry weight

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN JUNE 1987

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	4.14	4.62	0.43	1.67	0.30	0.30	0.10	0.58	0.17	0.17	0.06	0.33
2	MB	3	3.16	3.43	0.24	2.00	0.16	0.16	0.07	0.00	0.09	0.09	0.04	0.00
3	ML	3	4.69	5.11	0.38	15.00	0.10	0.27	0.20	1.00	0.06	0.15	0.11	0.58
4	MP	3	3.60	3.84	0.22	12.33	0.04	0.05	0.05	0.58	0.03	0.03	0.03	0.33
5	MR	3	3.17	3.50	0.30	28.67	0.14	0.26	0.11	2.89	0.08	0.15	0.07	1.67
6	OL	3	4.59	5.18	0.53	5.00	0.23	0.29	0.16	0.00	0.13	0.17	0.09	0.00
7	OP	3	3.85	4.43	0.52	8.00	0.06	0.16	0.13	0.00	0.03	0.09	0.08	0.00
8	SB	3	3.52	3.79	0.24	4.67	0.11	0.18	0.11	0.58	0.06	0.11	0.06	0.33
9	SL	3	2.72	3.02	0.27	2.00	0.14	0.06	0.07	0.00	0.08	0.04	0.04	0.00
10	YL	3	3.62	3.91	0.25	11.33	0.25	0.34	0.08	0.58	0.15	0.20	0.05	0.33
11	YP	3	2.63	2.73	0.09	3.67	0.09	0.19	0.08	0.58	0.05	0.11	0.05	0.33
12	YR	3	3.14	3.22	0.08	6.33	0.09	0.07	0.02	2.89	0.05	0.04	0.01	1.67

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN JULY 1987

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	MB	3	4.37	4.95	0.51	1.93	0.27	0.24	0.12	0.06	0.15	0.14	0.07	0.03
2	ML	3	5.53	7.65	1.91	17.23	0.57	1.21	0.68	3.26	0.33	0.70	0.39	1.88
3	MP	3	5.15	5.93	0.70	17.30	0.41	0.50	0.09	5.03	0.24	0.29	0.05	2.90
4	MR	3	4.90	5.38	0.43	13.63	0.13	0.13	0.08	4.02	0.07	0.08	0.05	2.32
5	OL	3	7.37	9.55	1.96	7.30	0.14	0.50	0.38	1.47	0.08	0.29	0.22	0.85
6	OP	3	6.01	7.04	0.93	9.47	0.28	0.34	0.16	2.80	0.16	0.20	0.09	1.62
7	SB	3	11.69	12.88	1.07	2.20	0.73	0.83	0.21	0.69	0.42	0.48	0.12	0.40
8	SL	3	12.43	13.97	1.39	3.40	1.34	1.43	0.08	0.61	0.77	0.82	0.05	0.35
9	YL	3	4.78	7.11	2.10	12.60	0.25	0.21	0.37	1.83	0.15	0.12	0.21	1.06
10	YP	3	4.19	4.73	0.49	5.93	0.22	0.26	0.03	0.95	0.13	0.15	0.02	0.55
11	YR	3	6.39	7.37	0.89	8.67	0.40	0.25	0.13	4.11	0.23	0.15	0.08	2.37

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN AUGUST 1987

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	7.08	8.52	1.30	7.87	0.67	0.56	0.11	0.21	0.38	0.32	0.06	0.12
2	MB	3	5.06	5.64	0.53	2.53	0.16	0.02	0.13	0.38	0.09	0.01	0.08	0.22
3	ML	3	6.19	8.01	1.64	9.13	0.07	0.15	0.17	0.91	0.04	0.09	0.10	0.52
4	MP	3	4.90	5.98	0.97	9.87	0.71	0.98	0.26	1.95	0.41	0.56	0.15	1.13
5	OL	3	4.49	5.37	0.80	5.87	0.05	0.05	0.01	1.70	0.03	0.03	0.01	0.98
6	OP	3	4.84	5.31	0.42	9.40	0.70	0.90	0.18	2.85	0.40	0.52	0.11	1.64
7	RT	3	5.10	5.55	0.40	38.83	0.11	0.08	0.04	1.88	0.07	0.05	0.02	1.08
8	SB	3	11.07	12.52	1.30	2.53	0.97	1.69	0.65	0.32	0.56	0.98	0.37	0.19
9	SL	3	9.22	10.23	0.91	3.57	0.98	1.03	0.07	0.97	0.57	0.60	0.04	0.56
10	YL	3	6.12	7.95	1.64	4.90	0.16	0.25	0.34	0.80	0.09	0.14	0.20	0.46
11	YP	3	4.68	5.38	0.63	5.50	0.21	0.46	0.26	1.48	0.12	0.27	0.15	0.85

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN SEPTEMBER 1987

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	8.63	10.44	1.63	3.90	0.34	0.22	0.36	0.46	0.20	0.13	0.21	0.26
2	MB	3	4.86	5.73	0.78	2.63	0.48	0.61	0.30	0.21	0.28	0.35	0.17	0.12
3	ML	3	5.92	10.61	4.22	18.33	0.33	0.43	0.42	0.35	0.19	0.25	0.24	0.20
4	MP	3	7.40	9.48	1.87	22.57	0.89	1.42	0.57	1.67	0.52	0.82	0.33	0.96
5	OL	3	4.97	6.04	0.96	3.57	0.11	0.14	0.03	0.45	0.06	0.08	0.02	0.26
6	OP	3	5.51	6.42	0.82	7.20	0.38	0.52	0.13	0.60	0.22	0.30	0.07	0.35
7	OSB	3	17.19	19.49	2.08	3.60	1.84	2.04	0.21	0.35	1.06	1.18	0.12	0.20
8	RT	3	4.18	4.90	0.65	23.03	0.38	0.63	0.24	1.53	0.22	0.37	0.14	0.88
9	SL	3	8.13	9.22	0.98	3.90	1.10	1.33	0.22	0.85	0.63	0.77	0.13	0.49
10	YL	3	3.72	5.27	1.39	5.53	0.56	1.30	0.71	1.00	0.32	0.75	0.41	0.58
11	YP	3	5.10	6.73	1.47	4.07	0.55	1.04	0.50	0.21	0.32	0.60	0.29	0.12
12	YSB	3	11.11	12.37	1.13	1.63	2.92	3.05	0.16	0.42	1.68	1.76	0.09	0.24

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN OCTOBER 1987

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	7.63	10.08	2.20	3.17	1.53	2.59	1.01	1.72	0.88	1.49	0.58	0.99
2	MB	3	5.05	5.94	0.80	2.53	0.07	0.26	0.20	0.12	0.04	0.15	0.12	0.07
3	ML	3	5.95	10.18	3.80	11.43	1.24	2.67	1.38	1.69	0.71	1.54	0.80	0.97
4	MP	3	8.38	13.94	5.00	15.73	1.20	3.65	2.24	0.68	0.70	2.11	1.29	0.39
5	OL	3	6.00	9.83	3.44	6.27	0.92	3.75	2.55	0.46	0.53	2.16	1.47	0.27
6	OP	3	7.96	10.78	2.54	12.53	0.76	1.26	0.62	1.33	0.44	0.73	0.36	0.77
7	OSB	3	18.72	26.10	6.64	3.77	2.01	4.18	4.97	1.07	1.16	2.41	2.87	0.62
8	RT	3	4.50	5.30	0.71	27.83	0.17	0.08	0.20	1.98	0.10	0.05	0.12	1.14
9	SL	3	11.54	13.39	1.67	4.50	1.10	1.41	0.36	0.75	0.63	0.81	0.21	0.44
10	YL	3	4.80	6.94	1.92	6.30	0.61	1.15	0.63	0.82	0.35	0.67	0.36	0.47
11	YP	3	5.05	6.24	1.07	4.53	0.52	0.59	0.16	0.75	0.30	0.34	0.09	0.43
12	YSB	3	7.56	8.85	1.16	1.43	0.48	0.53	0.04	0.32	0.28	0.30	0.03	0.19

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN NOVEMBER 1987

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	6.30	6.93	0.57	3.00	0.20	0.44	0.41	0.26	0.11	0.25	0.24	0.15
2	MB	3	4.66	4.95	0.26	2.30	0.18	0.09	0.14	0.10	0.10	0.05	0.08	0.06
3	ML	3	8.92	11.87	2.65	15.57	0.24	0.85	0.72	0.83	0.14	0.49	0.42	0.48
4	MP	3	6.17	7.93	1.58	18.60	0.33	0.31	0.41	1.82	0.19	0.18	0.23	1.05
5	OL	3	5.82	7.13	1.17	4.70	0.19	0.45	0.57	0.70	0.11	0.26	0.33	0.40
6	OP	3	6.01	7.39	1.25	9.70	0.47	0.75	0.38	1.28	0.27	0.43	0.22	0.74
7	OSB	3	10.80	11.97	1.05	2.87	0.41	0.75	0.64	0.75	0.23	0.44	0.37	0.43
8	RT	3	4.29	4.57	0.24	31.37	0.19	0.40	0.25	0.87	0.11	0.23	0.14	0.50
9	SL	3	9.68	10.53	0.76	3.97	2.38	2.65	0.58	0.92	1.38	1.53	0.34	0.53
10	YL	3	5.96	7.56	1.44	3.80	0.29	0.63	0.30	0.44	0.17	0.36	0.17	0.25
11	YP	3	4.82	5.35	0.47	2.50	0.98	1.45	0.51	0.40	0.57	0.84	0.30	0.23
12	YSB	3	7.93	8.89	0.86	1.63	0.26	0.30	0.17	0.23	0.15	0.13	0.10	0.13

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN DECEMBER 1987

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	4.65	5.19	0.48	1.23	0.12	0.35	0.24	0.35	0.07	0.20	0.14	0.20
2	MB	3	3.55	4.02	0.42	1.60	0.05	0.15	0.13	0.10	0.03	0.09	0.08	0.06
3	ML	3	7.28	9.38	1.89	19.83	0.42	0.25	0.19	0.68	0.24	0.15	0.11	0.39
4	MP	3	4.83	5.76	0.84	23.67	0.65	0.92	0.26	0.21	0.38	0.53	0.15	0.12
5	OL	3	4.89	6.55	1.50	2.30	0.70	0.44	0.62	0.75	0.40	0.25	0.36	0.44
6	OP	3	4.11	5.00	0.80	7.63	0.84	1.05	0.24	1.76	0.48	0.61	0.14	1.02
7	OSB	3	5.37	6.11	0.66	2.50	0.45	0.68	0.22	0.56	0.26	0.39	0.13	0.32
8	RT	3	4.00	4.36	0.32	29.97	0.12	0.44	0.29	2.16	0.07	0.25	0.17	1.25
9	SL	3	3.41	3.85	0.40	3.10	0.31	0.29	0.09	0.26	0.18	0.17	0.05	0.15
10	YL	3	4.31	5.43	1.00	4.30	0.30	0.50	0.31	0.66	0.12	0.29	0.18	0.38
11	YP	3	2.41	2.75	0.31	2.37	0.15	0.16	0.11	0.57	0.09	0.09	0.06	0.33
12	YSB	3	3.73	4.25	0.47	1.63	0.45	0.60	0.17	0.21	0.26	0.35	0.10	0.12

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN JANUARY 1988

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	3.42	4.62	1.08	0.50	0.16	0.22	0.05	0.36	0.09	0.12	0.03	0.21
2	MB	3	3.35	4.28	0.83	1.33	0.28	0.35	0.11	0.15	0.16	0.20	0.06	0.09
3	ML	3	3.41	4.70	1.16	15.30	0.25	0.42	0.22	2.36	0.15	0.24	0.13	1.37
4	MP	3	3.00	4.00	0.90	34.80	0.27	0.45	0.16	12.13	0.16	0.26	0.09	7.00
5	OL	3	3.75	5.03	1.15	3.17	0.11	0.21	0.25	0.93	0.06	0.12	0.14	0.54
6	OP	3	3.55	4.64	0.99	5.43	0.34	0.20	0.12	1.42	0.19	0.12	0.07	0.82
7	OSB	3	3.05	3.86	0.74	3.67	0.52	0.54	0.10	0.71	0.30	0.31	0.06	0.41
8	RT	3	3.67	4.80	1.01	26.87	0.20	0.27	0.07	5.30	0.12	0.16	0.04	3.06
9	SL	3	2.89	3.83	0.84	2.37	0.11	0.31	0.19	0.99	0.06	0.18	0.11	0.57
10	YL	3	2.77	3.61	0.75	3.33	0.16	0.30	0.17	0.49	0.09	0.17	0.10	0.28
11	YP	3	2.01	3.02	0.91	2.23	0.24	0.48	0.22	0.38	0.14	0.27	0.13	0.22
12	YSB	3	2.84	3.64	0.72	0.97	0.49	0.58	0.15	0.21	0.28	0.34	0.09	0.12

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN APRIL 1988

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	MB	3	2.89	3.25	0.32	5.37	0.15	0.33	0.19	0.12	0.09	0.19	0.11	0.07
2	ML	3	3.68	4.10	0.38	22.07	0.29	0.42	0.13	0.35	0.17	0.24	0.08	0.20
3	MP	3	3.03	3.36	0.30	18.30	0.15	0.28	0.30	0.17	0.09	0.16	0.18	0.10
4	OL	3	3.41	3.69	0.25	3.77	0.06	0.14	0.09	0.67	0.04	0.08	0.05	0.38
5	OP	3	2.87	3.41	0.49	5.27	0.11	0.18	0.13	0.23	0.07	0.11	0.07	0.13
6	RT	3	2.87	3.15	0.24	17.87	0.34	0.12	0.22	0.32	0.20	0.07	0.13	0.19
7	SB	3	3.02	3.43	0.37	5.40	0.22	0.25	0.26	0.17	0.13	0.14	0.15	0.10
8	SL	3	3.89	4.26	0.33	5.47	0.49	0.71	0.23	0.55	0.28	0.41	0.13	0.32
9	YL	3	2.52	2.86	0.31	10.60	0.16	0.27	0.23	1.06	0.09	0.16	0.13	0.61
10	YP	3	1.87	2.42	0.49	5.43	0.07	0.23	0.14	0.51	0.04	0.13	0.08	0.30

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN MAY 1988

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	MB	3	2.89	3.44	0.50	3.60	0.08	0.05	0.09	0.26	0.04	0.03	0.05	0.15
2	ML	3	4.73	5.55	0.74	27.77	0.13	0.22	0.08	0.21	0.07	0.13	0.05	0.12
3	MP	3	3.25	3.70	0.41	22.27	0.10	0.19	0.12	0.76	0.06	0.11	0.07	0.44
4	OL	3	4.53	5.32	0.71	1.73	0.54	0.80	0.26	0.47	0.31	0.46	0.15	0.27
5	OP	3	3.23	3.82	0.53	2.20	0.23	0.32	0.08	0.50	0.13	0.18	0.05	0.29
6	RT	3	3.50	4.04	0.48	18.87	0.16	0.04	0.14	0.83	0.09	0.02	0.08	0.48
7	SB	3	3.48	4.14	0.59	3.63	0.12	0.03	0.10	0.40	0.07	0.02	0.06	0.23
8	SL	3	2.86	3.38	0.47	4.27	0.11	0.06	0.11	0.32	0.06	0.04	0.06	0.19
9	YL	3	2.59	2.87	0.26	11.40	0.21	0.32	0.20	1.01	0.12	0.18	0.11	0.59
10	YP	3	1.96	2.35	0.35	3.77	0.08	0.06	0.03	0.40	0.04	0.03	0.02	0.23

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN JUNE 1988

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	MB	3	2.96	3.78	0.73	2.83	0.15	0.77	0.70	0.15	0.08	0.45	0.41	0.09
2	ML	3	3.96	4.85	0.80	26.33	0.45	0.57	0.19	1.72	0.26	0.33	0.11	0.99
3	MP	3	3.46	4.09	0.57	27.03	0.21	0.41	0.22	1.15	0.12	0.23	0.13	0.66
4	OL	3	4.48	5.34	0.77	3.43	0.69	0.64	0.04	0.26	0.40	0.37	0.02	0.15
5	OP	3	3.48	4.02	0.49	4.23	0.31	0.44	0.27	0.59	0.18	0.26	0.16	0.34
6	RT	3	3.18	3.55	0.34	12.13	0.32	0.30	0.14	1.06	0.19	0.11	0.08	0.61
7	SB	3	4.27	4.93	0.60	3.73	0.45	0.50	0.21	0.06	0.26	0.29	0.12	0.03
8	SL	3	4.37	4.86	0.44	4.20	0.36	0.24	0.18	0.89	0.21	0.14	0.10	0.51
9	YL	3	2.36	2.89	0.47	10.53	0.30	0.21	0.30	0.76	0.17	0.12	0.17	0.44
10	YP	3	2.44	2.83	0.39	5.13	0.16	0.07	0.21	0.58	0.09	0.04	0.12	0.33

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN JULY 1988

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	MB	3	3.55	4.09	0.49	2.53	0.26	0.17	0.10	0.42	0.15	0.10	0.06	0.24
2	ML	3	5.43	6.11	0.61	21.93	1.10	1.58	0.47	2.46	0.64	0.91	0.27	1.42
3	MP	3	4.11	4.94	0.75	45.37	0.32	0.49	0.16	7.68	0.19	0.29	0.09	4.44
4	OL	3	5.19	6.09	0.81	2.30	0.45	0.70	0.37	1.15	0.26	0.41	0.21	0.67
5	OP	3	4.18	5.16	0.88	4.00	0.64	0.99	0.32	1.49	0.37	0.57	0.18	0.86
6	RT	3	3.38	3.90	0.46	8.10	0.02	0.04	0.03	1.35	0.01	0.02	0.02	0.78
7	SB	3	6.69	7.59	0.81	3.97	1.00	1.16	0.16	0.64	0.58	0.67	0.09	0.37
8	SL	3	4.86	5.52	0.59	1.17	0.76	0.65	0.14	0.42	0.44	0.38	0.08	0.24
9	YL	3	3.13	3.53	0.36	6.47	0.23	0.34	0.11	1.19	0.13	0.20	0.07	0.69
10	YP	3	2.66	3.19	0.48	3.83	0.28	0.30	0.10	1.10	0.16	0.17	0.06	0.63

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN AUGUST 1980

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	MB	3	4.17	4.41	0.21	3.01	0.17	0.12	0.06	0.29	0.10	0.07	0.03	0.17
2	ML	3	5.84	6.62	0.70	18.15	0.40	0.33	0.15	0.73	0.23	0.19	0.09	0.42
3	MP	3	6.72	7.36	0.57	29.99	0.68	0.50	0.19	1.66	0.40	0.29	0.11	0.96
4	OL	3	4.58	5.05	0.42	3.50	0.32	0.48	0.15	0.76	0.18	0.28	0.09	0.44
5	OP	3	4.03	4.64	0.55	8.68	0.66	0.95	0.26	1.64	0.38	0.55	0.15	0.95
6	RT	3	4.14	4.55	0.37	17.26	0.16	0.14	0.08	1.63	0.09	0.08	0.05	0.94
7	SB	3	12.22	14.16	1.75	4.90	1.27	1.25	0.23	0.56	0.73	0.72	0.13	0.32
8	SL	3	10.20	11.34	1.02	3.87	2.36	2.66	0.28	1.00	1.36	1.53	0.16	0.58
9	YL	3	4.69	5.12	0.39	6.28	0.76	0.76	0.23	0.59	0.44	0.44	0.13	0.34
10	YP	3	3.93	4.26	0.30	4.32	0.18	0.32	0.13	0.39	0.10	0.19	0.08	0.23

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN SEPTEMBER 1980

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	7.30	8.35	0.94	8.86	0.20	0.24	0.18	0.59	0.12	0.14	0.11	0.34
2	MB	3	4.68	5.14	0.41	3.10	0.22	0.13	0.19	0.14	0.13	0.08	0.11	0.08
3	ML	3	6.64	8.53	1.70	11.57	0.42	0.70	0.34	0.75	0.24	0.40	0.20	0.43
4	MP	3	6.80	9.17	2.13	21.51	0.40	0.86	0.79	0.33	0.23	0.50	0.46	0.19
5	OL	3	4.50	5.44	0.85	4.52	0.22	0.66	0.54	0.59	0.13	0.38	0.31	0.34
6	OP	3	5.10	5.54	0.40	10.91	0.47	0.69	0.24	0.82	0.27	0.40	0.14	0.47
7	RT	3	4.71	4.99	0.25	28.08	0.23	0.26	0.05	1.71	0.13	0.15	0.03	0.99
8	SB	3	20.82	31.47	9.58	4.83	2.41	2.84	0.52	0.46	1.39	1.64	0.30	0.27
9	SL	3	13.54	14.85	1.18	4.01	1.31	1.24	0.10	0.48	0.76	0.72	0.06	0.28
10	YL	3	5.79	7.87	1.87	1.22	0.26	0.45	0.47	0.27	0.15	0.26	0.27	0.16
11	YP	3	5.71	7.60	1.71	1.34	0.54	1.51	0.88	0.47	0.31	0.87	0.51	0.27

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN OCTOBER 1988

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	6.04	6.65	0.55	7.66	0.36	0.29	0.28	1.85	0.21	0.17	0.16	1.07
2	MB	3	5.08	5.29	0.19	2.61	0.16	0.31	0.14	0.28	0.09	0.18	0.08	0.16
3	ML	3	7.88	10.47	2.33	5.82	0.09	0.53	0.48	1.29	0.05	0.31	0.27	0.74
4	MP	3	7.52	10.70	2.86	9.58	0.84	1.49	0.75	2.59	0.48	0.86	0.43	1.50
5	OL	3	4.84	5.07	0.21	8.89	1.10	1.03	0.15	0.43	0.64	0.59	0.09	0.25
6	OP	3	4.29	4.68	0.34	23.61	0.63	0.60	0.24	2.12	0.36	0.34	0.14	1.22
7	RT	3	4.67	4.84	0.16	31.79	0.25	0.44	0.17	4.03	0.14	0.25	0.10	2.32
8	SB	3	16.12	29.21	11.78	5.09	0.71	10.01	8.96	1.11	0.41	5.78	5.17	0.64
9	SL	3	12.74	18.36	5.06	2.21	2.27	2.30	1.02	0.36	1.31	1.33	0.59	0.21
10	YL	3	6.35	7.09	0.67	1.23	0.74	1.36	0.56	0.40	0.43	0.78	0.32	0.23
11	YP	3	5.93	7.04	1.00	1.46	0.86	1.29	0.47	0.51	0.50	0.74	0.27	0.29

CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
AMONG DIFFERENT PLANT PARTS, IN NOVEMBER 1988

OBS	PART	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	IN	3	4.19	4.92	0.66	10.16	0.72	1.10	0.54	0.46	0.41	0.64	0.31	0.27
2	MB	3	4.37	4.95	0.52	3.03	0.20	0.01	0.19	0.29	0.11	0.01	0.11	0.17
3	ML	3	6.16	6.66	0.45	7.61	0.97	0.98	0.33	0.18	0.56	0.56	0.19	0.11
4	MP	3	5.57	7.43	1.68	13.46	0.53	0.31	0.44	0.47	0.31	0.18	0.25	0.27
5	OL	3	3.57	4.39	0.73	5.39	0.12	0.06	0.16	1.66	0.07	0.04	0.09	0.96
6	OP	3	3.70	4.30	0.99	16.03	0.54	0.81	0.26	1.93	0.31	0.47	0.15	1.11
7	RT	3	4.51	4.93	0.38	31.59	0.26	0.23	0.15	2.10	0.15	0.14	0.09	1.21
8	SB	3	8.53	19.48	9.85	4.94	0.32	3.12	3.08	0.94	0.18	1.80	1.78	0.54
9	SL	3	4.42	5.62	1.08	2.05	0.45	0.89	0.47	0.17	0.26	0.52	0.27	0.10
10	YL	3	3.21	3.63	0.38	2.98	0.24	0.20	0.11	0.77	0.14	0.11	0.07	0.44
11	YP	3	2.89	3.17	0.25	2.70	0.41	0.55	0.14	0.88	0.23	0.32	0.08	0.51

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
IN YOUNG LEAVES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	3.64	3.81	0.15	11.33	0.24	0.42	0.17	0.58	0.14	0.25	0.10	0.33
2	14JUL87	3	4.78	7.11	2.10	12.60	0.25	0.21	0.37	1.83	0.15	0.12	0.21	1.06
3	17AUG87	3	6.12	7.95	1.64	4.90	0.16	0.25	0.34	0.80	0.09	0.14	0.20	0.46
4	22SEP87	3	3.72	5.27	1.39	5.53	0.56	1.30	0.71	1.00	0.32	0.75	0.41	0.58
5	19OCT87	3	4.80	6.94	1.92	6.30	0.61	1.15	0.63	0.82	0.35	0.67	0.36	0.47
6	13NOV87	3	5.96	7.56	1.44	3.80	0.29	0.63	0.30	0.44	0.17	0.36	0.17	0.25
7	18DEC87	3	4.31	5.43	1.00	4.20	0.20	0.50	0.31	0.66	0.12	0.29	0.18	0.38
8	20JAN88	3	2.77	3.61	0.75	3.33	0.16	0.30	0.17	0.49	0.09	0.17	0.10	0.28
9	18APR88	3	2.52	2.86	0.31	10.60	0.16	0.27	0.23	1.06	0.09	0.16	0.13	0.61
10	16MAY88	3	2.59	2.87	0.26	11.40	0.21	0.32	0.20	1.01	0.12	0.18	0.11	0.59
11	15JUN88	3	2.36	2.89	0.47	10.53	0.30	0.21	0.30	0.76	0.17	0.12	0.17	0.44
12	15JUL88	3	3.13	3.53	0.36	6.47	0.23	0.34	0.11	1.19	0.13	0.20	0.07	0.69
13	15AUG88	3	4.69	5.12	0.39	6.28	0.76	0.76	0.23	0.59	0.44	0.44	0.13	0.34
14	14SEP88	3	5.79	7.87	1.87	1.22	0.26	0.45	0.47	0.27	0.15	0.26	0.27	0.16
15	14OCT88	3	6.35	7.09	0.67	1.23	0.74	1.36	0.56	0.40	0.43	0.78	0.32	0.23
16	21NOV88	3	3.21	3.63	0.38	2.98	0.24	0.20	0.11	0.77	0.14	0.11	0.07	0.44

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
IN YOUNG PETIOLES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	2.63	2.63	0.00	3.67	0.09	0.28	0.16	0.58	0.05	0.16	0.10	0.33
2	14JUL87	3	4.19	4.73	0.49	5.93	0.22	0.26	0.03	0.95	0.13	0.15	0.02	0.55
3	17AUG87	3	4.68	5.38	0.63	5.50	0.21	0.46	0.26	1.48	0.12	0.27	0.15	0.85
4	22SEP87	3	5.10	6.73	1.47	4.07	0.55	1.04	0.50	0.21	0.32	0.60	0.29	0.12
5	19OCT87	3	5.05	6.24	1.07	4.53	0.52	0.59	0.16	0.75	0.30	0.34	0.09	0.43
6	13NOV87	3	4.82	5.35	0.47	2.50	0.98	1.45	0.51	0.40	0.57	0.84	0.30	0.23
7	18DEC87	3	2.41	2.75	0.31	2.37	0.15	0.16	0.11	0.57	0.09	0.09	0.06	0.33
8	20JAN88	3	2.01	3.02	0.91	2.23	0.24	0.48	0.22	0.38	0.14	0.27	0.13	0.22
9	18APR88	3	1.87	2.42	0.49	5.43	0.07	0.23	0.14	0.51	0.04	0.13	0.08	0.30
10	16MAY88	3	1.96	2.35	0.35	3.77	0.08	0.06	0.03	0.40	0.04	0.03	0.02	0.23
11	15JUN88	3	2.44	2.88	0.39	5.13	0.16	0.07	0.21	0.58	0.09	0.04	0.12	0.33
12	15JUL88	3	2.66	3.19	0.48	3.83	0.28	0.30	0.10	1.10	0.16	0.17	0.06	0.63
13	15AUG88	3	3.93	4.26	0.30	4.32	0.18	0.32	0.13	0.39	0.10	0.19	0.08	0.23
14	14SEP88	3	5.71	7.60	1.71	1.34	0.54	1.51	0.88	0.47	0.31	0.87	0.51	0.27
15	14OCT88	3	5.93	7.04	1.00	1.46	0.86	1.29	0.47	0.51	0.50	0.74	0.27	0.29
16	21NOV88	3	2.89	3.17	0.25	2.70	0.41	0.55	0.14	0.88	0.23	0.32	0.08	0.51

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION IN MATURE LEAVES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	4.69	5.05	0.32	15.00	0.10	0.35	0.29	1.00	0.06	0.20	0.17	0.58
2	14JUL87	3	5.53	7.65	1.91	17.23	0.57	1.21	0.68	3.26	0.33	0.70	0.39	1.88
3	17AUG87	3	6.19	8.01	1.64	9.13	0.07	0.15	0.17	0.91	0.04	0.09	0.10	0.52
4	22SEP87	3	5.92	10.61	4.22	18.33	0.33	0.43	0.42	0.35	0.19	0.25	0.24	0.20
5	19OCT87	3	5.95	10.18	3.80	11.43	1.24	2.67	1.38	1.69	0.71	1.54	0.80	0.97
6	13NOV87	3	8.92	11.87	2.65	15.57	0.24	0.85	0.72	0.83	0.14	0.49	0.42	0.48
7	18DEC87	3	7.28	9.38	1.89	19.83	0.42	0.25	0.19	0.68	0.24	0.15	0.11	0.39
8	20JAN88	3	3.41	4.70	1.16	15.30	0.25	0.42	0.22	2.36	0.15	0.24	0.13	1.37
9	18APR88	3	3.68	4.10	0.38	22.07	0.29	0.42	0.13	0.35	0.17	0.24	0.08	0.20
10	16MAY88	3	4.73	5.55	0.74	27.77	0.13	0.22	0.08	0.21	0.07	0.13	0.05	0.12
11	15JUN88	3	3.96	4.85	0.80	26.33	0.45	0.57	0.19	1.72	0.26	0.33	0.11	0.99
12	15JUL88	3	5.43	6.11	0.61	21.93	1.10	1.58	0.47	2.46	0.64	0.91	0.27	1.42
13	15AUG88	3	5.84	6.62	0.70	18.15	0.40	0.33	0.15	0.73	0.23	0.19	0.09	0.42
14	14SEP88	3	6.64	8.53	1.70	11.57	0.42	0.70	0.34	0.75	0.24	0.40	0.20	0.43
15	14OCT88	3	7.88	10.47	2.33	5.82	0.09	0.53	0.48	1.29	0.05	0.31	0.27	0.74
16	21NOV88	3	6.16	6.66	0.45	7.61	0.97	0.98	0.33	0.18	0.56	0.56	0.19	0.11

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION IN MATURE PETIOLES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	3.60	3.84	0.22	12.33	0.04	0.05	0.05	0.58	0.03	0.03	0.03	0.33
2	14JUL87	3	5.15	5.93	0.70	17.30	0.41	0.50	0.09	5.03	0.24	0.29	0.05	2.90
3	17AUG87	3	4.90	5.98	0.97	9.87	0.71	0.98	0.26	1.95	0.41	0.56	0.15	1.13
4	22SEP87	3	7.40	9.48	1.87	22.57	0.89	1.42	0.57	1.67	0.52	0.82	0.33	0.96
5	19OCT87	3	8.38	13.94	5.00	15.73	1.20	3.65	2.24	0.68	0.70	2.11	1.29	0.39
6	13NOV87	3	6.17	7.93	1.58	18.60	0.33	0.31	0.41	1.82	0.19	0.18	0.23	1.05
7	18DEC87	3	4.83	5.76	0.84	23.67	0.65	0.92	0.26	0.21	0.38	0.53	0.15	0.12
8	20JAN88	3	3.00	4.00	0.90	34.80	0.27	0.45	0.16	12.13	0.16	0.26	0.09	7.00
9	18APR88	3	3.03	3.36	0.30	18.30	0.15	0.28	0.30	0.17	0.09	0.16	0.18	0.10
10	16MAY88	3	3.25	3.70	0.41	22.27	0.10	0.19	0.12	0.76	0.06	0.11	0.07	0.44
11	15JUN88	3	3.46	4.09	0.57	27.03	0.21	0.41	0.22	1.15	0.12	0.23	0.13	0.66
12	15JUL88	3	4.11	4.94	0.75	45.37	0.32	0.49	0.16	7.68	0.19	0.29	0.09	4.44
13	15AUG88	3	6.72	7.36	0.57	29.99	0.68	0.50	0.19	1.66	0.40	0.29	0.11	0.96
14	14SEP88	3	6.80	9.17	2.13	21.51	0.40	0.86	0.79	0.33	0.23	0.50	0.46	0.19
15	14OCT88	3	7.52	10.70	2.86	9.58	0.84	1.49	0.75	2.59	0.48	0.86	0.43	1.50
16	21NOV88	3	5.57	7.43	1.68	13.46	0.53	0.31	0.44	0.47	0.31	0.18	0.25	0.27

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
IN OLD LEAVES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	4.59	5.18	0.53	5.00	0.23	0.29	0.16	0.00	0.13	0.17	0.09	0.00
2	14JUL87	3	7.37	9.55	1.96	7.30	0.14	0.50	0.38	1.47	0.08	0.29	0.22	0.85
3	17AUG87	3	4.49	5.37	0.80	5.87	0.05	0.05	0.01	1.70	0.03	0.03	0.01	0.98
4	22SEP87	3	4.97	6.04	0.96	3.57	0.11	0.14	0.03	0.45	0.06	0.08	0.02	0.26
5	19OCT87	3	6.00	9.83	3.44	6.27	0.92	3.75	2.55	0.46	0.53	2.16	1.47	0.27
6	13NOV87	3	5.82	7.13	1.17	4.70	0.19	0.45	0.57	0.70	0.11	0.26	0.33	0.40
7	18DEC87	3	4.89	6.55	1.50	2.30	0.70	0.44	0.62	0.75	0.40	0.25	0.36	0.44
8	20JAN88	3	3.75	5.03	1.15	3.17	0.11	0.21	0.25	0.93	0.06	0.12	0.14	0.54
9	16APR88	3	3.41	3.69	0.25	3.77	0.06	0.14	0.09	0.67	0.04	0.08	0.05	0.39
10	16MAY88	3	4.53	5.32	0.71	1.73	0.54	0.60	0.26	0.47	0.31	0.46	0.15	0.27
11	15JUN88	3	4.48	5.34	0.77	3.43	0.69	0.64	0.04	0.26	0.40	0.37	0.02	0.15
12	15JUL88	3	5.19	6.09	0.81	2.30	0.45	0.70	0.37	1.15	0.26	0.41	0.21	0.67
13	15AUG88	3	4.58	5.05	0.42	3.50	0.32	0.48	0.15	0.76	0.18	0.28	0.09	0.44
14	14SEP88	3	4.50	5.44	0.85	4.52	0.22	0.66	0.54	0.59	0.13	0.38	0.31	0.34
15	14OCT88	3	4.84	5.07	0.21	8.89	1.10	1.03	0.15	0.43	0.64	0.59	0.09	0.25
16	21NOV88	3	3.57	4.39	0.73	5.39	0.12	0.06	0.16	1.66	0.07	0.04	0.09	0.96

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
IN OLD PETIOLES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	3.85	4.43	0.52	8.00	0.06	0.16	0.13	0.00	0.03	0.09	0.08	0.00
2	14JUL87	3	6.01	7.04	0.93	9.47	0.28	0.34	0.16	2.80	0.16	0.20	0.09	1.62
3	17AUG87	3	4.84	5.31	0.42	9.40	0.70	0.90	0.18	2.85	0.40	0.52	0.11	1.64
4	22SEP87	3	5.51	6.42	0.82	7.20	0.38	0.52	0.13	0.60	0.22	0.30	0.07	0.35
5	19OCT87	3	7.96	10.78	2.54	12.53	0.76	1.26	0.62	1.33	0.44	0.73	0.36	0.77
6	13NOV87	3	6.01	7.39	1.25	9.70	0.47	0.75	0.38	1.28	0.27	0.43	0.22	0.74
7	18DEC87	3	4.11	5.00	0.80	7.63	0.84	1.05	0.24	1.76	0.48	0.61	0.14	1.02
8	20JAN88	3	3.55	4.64	0.99	5.43	0.34	0.20	0.12	1.42	0.19	0.12	0.07	0.82
9	18APR88	3	2.87	3.41	0.49	5.27	0.11	0.18	0.13	0.23	0.07	0.11	0.07	0.13
10	16MAY88	3	3.23	3.82	0.53	2.20	0.23	0.32	0.08	0.50	0.13	0.18	0.05	0.29
11	15JUN88	3	3.48	4.02	0.49	4.23	0.31	0.44	0.27	0.59	0.18	0.26	0.16	0.34
12	15JUL88	3	4.18	5.16	0.88	4.00	0.64	0.99	0.32	1.49	0.37	0.57	0.18	0.86
13	15AUG88	3	4.03	4.64	0.55	8.68	0.66	0.95	0.26	1.64	0.38	0.55	0.15	0.95
14	14SEP88	3	5.10	5.54	0.40	10.91	0.47	0.69	0.24	0.82	0.27	0.40	0.14	0.47
15	14OCT88	3	4.29	4.68	0.34	23.61	0.63	0.60	0.24	2.12	0.36	0.34	0.14	1.22
16	21NOV88	3	3.70	4.30	0.99	16.03	0.54	0.81	0.26	1.93	0.31	0.47	0.15	1.11

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION IN STEM-BASES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	3.52	3.73	0.19	4.67	0.11	0.28	0.17	0.58	0.06	0.16	0.10	0.33
2	14JUL87	3	11.69	12.88	1.07	2.20	0.73	0.83	0.21	0.69	0.42	0.48	0.12	0.40
3	17AUG87	3	11.07	12.52	1.30	2.53	0.97	1.69	0.65	0.32	0.56	0.98	0.37	0.19
4	22SEP87	3	17.19	19.49	2.08	3.60	1.84	2.04	0.21	0.35	1.06	1.18	0.12	0.20
5	19OCT87	3	18.72	26.10	6.64	3.77	2.01	4.18	4.97	1.07	1.16	2.41	2.87	0.62
6	13NOV87	3	10.80	11.97	1.05	2.87	0.41	0.75	0.64	0.75	0.23	0.44	0.37	0.43
7	18DEC87	3	5.37	6.11	0.66	2.50	0.45	0.68	0.22	0.56	0.26	0.39	0.13	0.32
8	20JAN88	3	3.05	3.86	0.74	3.67	0.52	0.54	0.10	0.71	0.30	0.31	0.06	0.41
9	18FEB88	3	2.45	3.48	0.93	15.83	0.23	0.09	0.25	1.67	0.13	0.05	0.14	0.96
10	21MAR88	3	2.46	3.40	0.85	17.63	0.13	0.14	0.02	1.92	0.08	0.08	0.01	1.11
11	18APR88	3	3.02	3.43	0.37	5.40	0.22	0.25	0.26	0.17	0.13	0.14	0.15	0.10
12	16MAY88	3	3.48	4.14	0.59	3.63	0.12	0.03	0.10	0.40	0.07	0.02	0.06	0.23
13	15JUN88	3	4.27	4.93	0.60	3.73	0.45	0.50	0.21	0.06	0.26	0.29	0.12	0.03
14	15JUL88	3	6.69	7.59	0.81	3.97	1.00	1.16	0.16	0.64	0.58	0.67	0.09	0.37
15	15AUG88	3	12.22	14.16	1.75	4.90	1.27	1.25	0.23	0.56	0.73	0.72	0.13	0.32
16	14SEP88	3	20.82	31.47	9.58	4.83	2.41	2.84	0.52	0.46	1.39	1.64	0.30	0.27
17	14OCT88	3	16.12	29.21	11.78	5.09	0.71	10.01	8.96	1.11	0.41	5.78	5.17	0.64
18	21NOV88	3	8.53	19.48	9.85	4.94	0.32	3.12	3.08	0.94	0.18	1.80	1.78	0.54

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION IN ROOTS

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	3.17	3.50	0.30	28.67	0.14	0.26	0.11	2.89	0.08	0.15	0.07	1.67
2	14JUL87	3	4.90	5.38	0.43	13.63	0.13	0.13	0.08	4.02	0.07	0.08	0.05	2.32
3	17AUG87	3	5.10	5.55	0.40	38.83	0.11	0.08	0.04	1.88	0.07	0.05	0.02	1.08
4	22SEP87	3	4.18	4.90	0.65	23.03	0.38	0.63	0.24	1.53	0.22	0.37	0.14	0.88
5	19OCT87	3	4.50	5.30	0.71	27.83	0.17	0.08	0.20	1.98	0.10	0.05	0.12	1.14
6	13NOV87	3	4.29	4.57	0.24	31.37	0.19	0.40	0.25	0.87	0.11	0.23	0.14	0.50
7	18DEC87	3	4.00	4.36	0.32	29.97	0.12	0.44	0.29	2.16	0.07	0.25	0.17	1.25
8	20JAN88	3	3.67	4.80	1.01	26.87	0.20	0.27	0.07	5.30	0.12	0.16	0.04	3.06
9	18APR88	3	2.87	3.15	0.24	17.87	0.34	0.12	0.22	0.32	0.20	0.07	0.13	0.19
10	16MAY88	3	3.50	4.04	0.48	18.87	0.16	0.04	0.14	0.83	0.09	0.02	0.08	0.48
11	15JUN88	3	3.18	3.55	0.34	12.13	0.32	0.20	0.14	1.06	0.19	0.11	0.08	0.61
12	15JUL88	3	3.38	3.90	0.46	8.10	0.02	0.04	0.03	1.35	0.01	0.02	0.02	0.78
13	15AUG88	3	4.14	4.55	0.37	17.26	0.16	0.14	0.08	1.63	0.09	0.08	0.05	0.94
14	14SEP88	3	4.71	4.99	0.25	28.08	0.23	0.26	0.05	1.71	0.13	0.15	0.03	0.99
15	14OCT88	3	4.67	4.84	0.16	31.79	0.25	0.44	0.17	4.03	0.14	0.25	0.10	2.32
16	21NOV88	3	4.51	4.93	0.38	31.59	0.26	0.23	0.15	2.10	0.15	0.14	0.09	1.21

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION IN STOLONS

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	2.72	2.98	0.23	2.00	0.14	0.05	0.14	0.00	0.08	0.03	0.08	0.00
2	14JUL87	3	12.43	13.97	1.39	3.40	1.34	1.43	0.08	0.61	0.77	0.82	0.05	0.35
3	17AUG87	3	9.22	10.23	0.91	3.57	0.98	1.03	0.07	0.97	0.57	0.60	0.04	0.56
4	22SEP87	3	8.13	9.22	0.98	3.90	1.10	1.33	0.22	0.85	0.63	0.77	0.13	0.49
5	19OCT87	3	11.54	13.39	1.67	4.50	1.10	1.41	0.36	0.75	0.63	0.81	0.21	0.44
6	13NOV87	3	9.68	10.53	0.76	3.97	2.33	2.65	0.58	0.92	1.38	1.53	0.34	0.53
7	18DEC87	3	3.41	3.85	0.40	3.10	0.31	0.29	0.09	0.26	0.18	0.17	0.05	0.15
8	20JAN88	3	2.89	3.83	0.84	2.37	0.11	0.31	0.19	0.99	0.06	0.18	0.11	0.57
9	18APR88	3	3.89	4.26	0.33	5.47	0.49	0.71	0.23	0.55	0.28	0.41	0.13	0.32
10	16MAY88	3	2.66	3.38	0.47	4.27	0.11	0.06	0.11	0.32	0.06	0.04	0.06	0.19
11	15JUN88	3	4.37	4.86	0.44	4.20	0.36	0.24	0.18	0.89	0.21	0.14	0.10	0.51
12	15JUL88	3	4.86	5.52	0.59	1.17	0.76	0.65	0.14	0.42	0.44	0.38	0.08	0.24
13	15AUG88	3	10.20	11.34	1.02	3.87	2.36	2.66	0.28	1.00	1.36	1.53	0.16	0.58
14	14SEP88	3	13.54	14.85	1.18	4.01	1.31	1.24	0.10	0.48	0.76	0.72	0.06	0.28
15	14OCT88	3	12.74	18.36	5.06	2.21	2.27	2.30	1.02	0.36	1.31	1.33	0.59	0.21
16	21NOV88	3	4.42	5.62	1.08	2.05	0.45	0.89	0.47	0.17	0.26	0.52	0.27	0.10

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION IN MEMBRANES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	3.19	3.40	0.19	2.00	0.12	0.21	0.11	0.00	0.07	0.12	0.07	0.00
2	14JUL87	3	4.37	4.95	0.51	1.93	0.27	0.24	0.12	0.06	0.15	0.14	0.07	0.03
3	17AUG87	3	5.06	5.64	0.53	2.53	0.16	0.02	0.13	0.38	0.09	0.01	0.08	0.22
4	22SEP87	3	4.86	5.73	0.78	2.63	0.48	0.61	0.30	0.21	0.28	0.35	0.17	0.12
5	19OCT87	3	5.05	5.94	0.80	2.53	0.07	0.26	0.20	0.12	0.04	0.15	0.12	0.07
6	13NOV87	3	4.66	4.95	0.26	2.30	0.18	0.09	0.14	0.10	0.10	0.05	0.08	0.06
7	18DEC87	3	3.55	4.02	0.42	1.60	0.05	0.15	0.13	0.10	0.03	0.09	0.08	0.06
8	20JAN88	3	3.35	4.28	0.83	1.33	0.28	0.35	0.11	0.15	0.16	0.20	0.06	0.09
9	18APR88	3	2.89	3.25	0.32	5.37	0.15	0.33	0.19	0.12	0.09	0.19	0.11	0.07
10	16MAY88	3	2.89	3.44	0.50	3.60	0.08	0.05	0.09	0.26	0.04	0.03	0.05	0.15
11	15JUN88	3	2.96	3.78	0.73	2.83	0.15	0.77	0.70	0.15	0.08	0.45	0.41	0.09
12	15JUL88	3	3.55	4.09	0.49	2.53	0.26	0.17	0.10	0.42	0.15	0.10	0.06	0.24
13	15AUG88	3	4.17	4.41	0.21	3.01	0.17	0.12	0.06	0.29	0.10	0.07	0.03	0.17
14	14SEP88	3	4.68	5.14	0.41	3.10	0.22	0.13	0.19	0.14	0.13	0.08	0.11	0.08
15	14OCT88	3	5.08	5.29	0.19	2.61	0.16	0.31	0.14	0.28	0.09	0.18	0.08	0.16
16	21NOV88	3	4.37	4.95	0.52	3.03	0.20	0.01	0.19	0.29	0.11	0.01	0.11	0.17

SEASONAL CARBOHYDRATE CONCENTRATIONS AND DRY WEIGHT DISTRIBUTION
IN INFLORESCENCES

OBS	DATE	N	MPFREE	MPTOT	MPSTAR	MPDW	SDPFREE	SDPTOT	SDPSTAR	SDPDW	SEPFREE	SEPTOT	SEPSTAR	SEPDW
1	11JUN87	3	4.14	4.62	0.43	1.67	0.30	0.30	0.10	0.58	0.17	0.17	0.06	0.33
2	17AUG87	3	7.08	8.52	1.30	7.87	0.67	0.56	0.11	0.21	0.38	0.32	0.06	0.12
3	22SEP87	3	8.63	10.44	1.63	3.90	0.34	0.22	0.36	0.46	0.20	0.13	0.21	0.26
4	19OCT87	3	7.63	10.08	2.20	3.17	1.53	2.59	1.01	1.72	0.88	1.49	0.58	0.99
5	13NOV87	3	6.30	6.93	0.57	3.00	0.20	0.44	0.41	0.26	0.11	0.25	0.24	0.15
6	18DEC87	3	4.65	5.19	0.48	1.23	0.12	0.35	0.24	0.35	0.07	0.20	0.14	0.20
7	20JAN88	3	3.42	4.62	1.08	0.50	0.16	0.22	0.05	0.36	0.09	0.12	0.03	0.21
8	14SEP88	3	7.30	8.35	0.94	8.86	0.20	0.24	0.18	0.59	0.12	0.14	0.11	0.34
9	14OCT88	3	6.04	6.65	0.55	7.66	0.36	0.29	0.28	1.85	0.21	0.17	0.16	1.07
10	21NOV88	3	4.19	4.92	0.66	10.16	0.72	1.10	0.54	0.46	0.41	0.64	0.31	0.27

APPENDIX B: DAILY MEANS OF WATER AND AIR TEMPERATURES

Key

Symbol	Explanation
OBS	Observation
WMAX	Maximum water temperatures (°C)
WMIN	Minimum water temperatures (°C)
AMAX	Maximum air temperatures (°C)
AMIN	Minimum air temperatures (°C)

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
1	6	1	87	32	28	40	21
2	6	2	87	32	27	40	22
3	6	3	87	33	29	44	22
4	6	4	87	32	28	41	22
5	6	5	87	31	27	36	17
6	6	6	87	31	26	42	17
7	6	7	87	32	28	43	19
8	6	8	87	32	28	41	18
9	6	9	87	32	28	41	20
10	6	10	87	32	28	41	20
11	6	11	87	31	28	39	20
12	6	12	87	30	28	40	22
13	6	13	87	29	26	29	21
14	6	14	87	31	27	33	22
15	6	15	87	32	27	43	21
16	6	16	87	32	27	38	21
17	6	17	87	32	28	41	22
18	6	18	87	33	28	42	21
19	6	19	87	31	27	33	22
20	6	20	87	32	27	44	19
21	6	21	87	32	28	43	22
22	6	22	87	33	28	44	22
23	6	23	87	33	29	48	22
24	6	24	87	33	29	43	22
25	6	25	87	33	29	42	22
26	6	26	87	33	29	46	22
27	6	27	87	31	27	40	17
28	6	28	87	31	27	42	17
29	6	29	87	32	28	46	19
30	6	30	87	32	29	43	22
31	7	1	87	33	28	39	21
32	7	2	87	31	28	31	22
33	7	3	87	31	28	39	21
34	7	4	87	32	29	42	22
35	7	5	87	31	29	42	22
36	7	6	87	32	28	43	22
37	7	7	87	31	27	31	20
38	7	8	87	30	28	38	21
39	7	9	87	30	27	43	21
40	7	10	87	31	28	48	22
41	7	11	87	31	28	44	22
42	7	12	87	33	29	46	22
43	7	13	87	33	29	43	23
44	7	14	87	32	29	41	22
45	7	15	87	31	27	38	17
46	7	16	87	31	26	42	17
47	7	17	87	30	28	48	20
48	7	18	87	31	29	43	21
49	7	19	87	32	28	46	20
50	7	20	87	31	28	39	20
51	7	21	87	31	28	43	21
52	7	22	87	31	28	42	22
53	7	23	87	31	29	42	21
54	7	24	87	32	28	46	22
55	7	25	87	32	28	48	21

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
56	7	26	87	32	29	40	21
57	7	27	87	32	29	46	22
58	7	28	87	32	29	43	24
59	7	29	87	34	30	42	24
60	7	30	87	33	29	44	23
61	7	31	87	33	28	42	22
62	8	1	87	33	29	44	22
63	8	2	87	32	29	41	24
64	8	3	87	33	29	43	23
65	8	4	87	33	29	43	22
66	8	5	87	33	29	43	23
67	8	6	87	32	28	43	22
68	8	7	87	33	28	46	22
69	8	8	87	32	26	46	21
70	8	9	87	32	27	44	23
71	8	10	87	31	28	33	23
72	8	11	87	31	26	33	23
73	8	12	87	31	26	38	23
74	8	13	87	31	26	31	24
75	8	14	87	30	25	38	23
76	8	15	87	31	26	37	21
77	8	16	87	31	27	43	22
78	8	17	87	32	28	42	23
79	8	18	87	34	29	42	23
80	8	19	87	32	28	42	21
81	8	20	87	32	28	43	21
82	8	21	87	32	28	47	21
83	8	22	87	32	28	49	21
84	8	23	87	32	28	43	21
85	8	24	87	32	28	44	23
86	8	25	87	32	28	44	22
87	8	26	87	32	28	44	22
88	8	27	87	32	28	46	23
89	8	28	87	31	26	38	21
90	8	29	87	29	26	38	20
91	8	30	87	29	26	38	20
92	8	31	87	27	26	28	20
93	9	1	87	29	24	37	18
94	9	2	87	28	21	42	14
95	9	3	87	28	22	44	14
96	9	4	87	28	22	44	16
97	9	5	87	28	24	44	17
98	9	6	87	28	24	41	18
99	9	7	87	29	25	43	18
100	9	8	87	29	25	39	20
101	9	9	87	29	25	41	20
102	9	10	87	31	25	41	20
103	9	11	87	29	26	29	20
104	9	12	87	33	24	37	18
105	9	13	87	29	27	40	20
106	9	14	87	30	27	42	19
107	9	15	87	30	27	41	21
108	9	16	87	29	26	33	21
109	9	17	87	28	25	32	20
110	9	18	87	26	24	29	20

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
111	9	19	87	26	22	34	19
112	9	20	87	25	21	41	12
113	9	21	87	25	21	43	13
114	9	22	87	26	21	44	14
115	9	23	87	24	19	38	11
116	9	24	87	24	19	38	11
117	9	25	87	24	19	42	12
118	9	26	87	25	20	41	12
119	9	27	87	26	20	40	12
120	9	28	87	26	22	40	17
121	9	29	87	25	23	31	20
122	9	30	87	25	20	32	14
123	10	1	87	24	18	37	10
124	10	2	87	25	19	40	21
125	10	3	87	25	20	38	8
126	10	4	87	28	17	37	4
127	10	5	87	21	17	38	4
128	10	6	87	22	16	37	11
129	10	7	87	22	17	27	6
130	10	8	87	23	15	37	3
131	10	9	87	24	17	38	7
132	10	10	87	25	21	39	8
133	10	11	87	25	21	40	9
134	10	12	87	25	20	29	7
135	10	13	87	23	14	29	2
136	10	14	87	23	17	36	3
137	10	15	87	24	17	38	4
138	10	16	87	24	19	39	4
139	10	17	87	25	20	33	7
140	10	18	87	26	23	33	11
141	10	19	87	27	24	37	16
142	10	20	87	27	22	34	14
143	10	21	87	25	16	24	4
144	10	22	87	20	12	21	1
145	10	23	87	19	14	38	8
146	10	24	87	20	19	37	12
147	10	25	87	21	18	23	13
148	10	26	87	21	20	26	13
149	10	27	87	21	18	26	11
150	10	28	87	20	14	27	1
151	10	29	87	19	14	28	2
152	10	30	87	20	15	39	7
153	10	31	87	22	17	41	6
154	11	1	87	21	20	40	6
155	11	2	87	22	19	42	7
156	11	3	87	24	19	38	9
157	11	4	87	26	21	34	12
158	11	5	87	25	22	28	10
159	11	6	87	25	15	33	8
160	11	7	87	24	18	31	3
161	11	8	87	25	21	26	14
162	11	9	87	25	22	24	16
163	11	10	87	23	16	24	4
164	11	11	87	16	8	18	-1
165	11	12	87	16	9	24	-3

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
166	11	13	87	17	12	30	-2
167	11	14	87	20	14	30	0
168	11	15	87	24	19	28	12
169	11	16	87	25	20	22	13
170	11	17	87	23	18	24	10
171	11	18	87	24	16	23	2
172	11	19	87	22	14	22	7
173	11	20	87	22	12	20	3
174	11	21	87	21	10	27	-2
175	11	22	87	20	12	28	-1
176	11	23	87	24	16	31	10
177	11	24	87	25	19	28	13
178	11	25	87	26	20	30	14
179	11	26	87	25	20	13	13
180	11	27	87	25	18	13	10
181	11	28	87	23	16	17	6
182	11	29	87	20	13	14	-1
183	11	30	87	19	13	16	6
184	12	1	87	19	11	24	0
185	12	2	87	19	14	22	-2
186	12	3	87	19	13	24	1
187	12	4	87	20	17	23	2
188	12	5	87	21	13	22	-1
189	12	6	87	21	17	29	7
190	12	7	87	22	18	20	13
191	12	8	87	23	17	27	18
192	12	9	87	24	17	26	11
193	12	10	87	24	17	26	1
194	12	11	87	23	17	27	3
195	12	12	87	24	18	28	4
196	12	13	87	23	19	28	7
197	12	14	87	25	19	29	13
198	12	15	87	25	19	24	0
199	12	16	87	20	12	12	-2
200	12	17	87	17	7	16	-6
201	12	18	87	17	8	10	-1
202	12	19	87	24	12	18	4
203	12	20	87	23	19	21	4
204	12	21	87	22	20	13	6
205	12	22	87	22	13	13	7
206	12	23	87	20	18	22	2
207	12	24	87	21	17	23	14
208	12	25	87	22	20	24	18
209	12	26	87	22	18	27	6
210	12	27	87	20	18	14	10
211	12	28	87	20	18	13	1
212	12	29	87	19	15	9	-1
213	12	30	87	18	14	11	-3
214	12	31	87	18	10	14	8
215	1	1	88	19	16	13	0
216	1	2	88	17	14	6	-2
217	1	3	88	16	14	3	0
218	1	4	88	17	14	13	0
219	1	5	88	16	7	8	-2
220	1	6	88	15	4	2	-4

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
221	1	7	88	13	4	0	-4
222	1	8	88	11	9	-4	-7
223	1	9	88	11	2	1	-7
224	1	10	88	12	9	9	-8
225	1	11	88	14	10	21	-9
226	1	12	88	16	9	14	-3
227	1	13	88	16	13	14	-2
228	1	14	88	15	5	8	-6
229	1	15	88	15	7	17	-7
230	1	16	88	16	11	17	-3
231	1	17	88	20	13	21	11
232	1	18	88	21	17	24	9
233	1	19	88	21	19	22	17
234	1	20	88	20	16	20	3
235	1	21	88	18	11	13	-2
236	1	22	88	15	7	17	-7
237	1	23	88	15	8	20	-6
238	1	24	88	20	11	20	4
239	1	25	88	17	14	21	-2
240	1	26	88	15	6	15	-7
241	1	27	88	14	7	20	-8
242	1	28	88	16	9	27	-4
243	1	29	88	18	12	24	2
244	1	30	88	20	14	29	7
245	1	31	88	21	18	24	13
246	2	1	88	20	19	21	16
247	2	2	88	20	17	21	10
248	2	3	88	19	14	13	7
249	2	4	88	19	15	10	3
250	2	5	88	16	12	2	-2
251	2	6	88	13	7	7	-6
252	2	7	88	10	2	2	-11
253	2	8	88	12	6	14	-1
254	2	9	88	16	10	21	-2
255	2	10	88	17	10	27	-3
256	2	11	88	17	12	28	-4
257	2	12	88	13	3	13	-9
258	2	13	88	16	9	29	2
259	2	14	88	17	13	24	3
260	2	15	88	18	14	14	3
261	2	16	88	18	12	28	-4
262	2	17	88	20	14	30	1
263	2	18	88	18	16	16	7
264	2	19	88	16	15	10	6
265	2	20	88	18	14	19	2
266	2	21	88	20	14	23	0
267	2	22	88	20	15	28	4
268	2	23	88	20	18	27	7
269	2	24	88	19	14	18	0
270	2	25	88	19	13	22	-2
271	2	26	88	20	14	24	-1
272	2	28	88	24	16	30	10
273	2	29	88	22	18	28	10
274	3	1	88	22	17	30	3
275	3	2	88	22	18	33	7

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
276	3	3	88	26	20	30	14
277	3	4	88	24	18	28	4
278	3	5	88	20	14	24	1
279	3	6	88	20	15	24	1
280	3	7	88	23	15	31	0
281	3	8	88	22	20	30	12
282	3	9	88	21	19	19	7
283	3	10	88	22	17	29	3
284	3	11	88	23	17	32	3
285	3	12	88	22	20	29	14
286	3	13	88	23	16	21	3
287	3	14	88	21	12	24	-1
288	3	15	88	16	12	16	-6
289	3	16	88	19	11	27	-4
290	3	17	88	19	13	26	1
291	3	18	88	18	12	19	3
292	3	19	88	17	11	19	-2
293	3	20	88	20	14	27	1
294	3	21	88	21	14	30	8
295	3	22	88	23	17	31	6
296	3	23	88	24	19	36	10
297	3	24	88	24	19	32	13
298	3	25	88	24	20	28	13
299	3	26	88	24	19	32	13
300	3	27	88	24	18	39	4
301	3	28	88	24	18	34	7
302	3	29	88	24	20	29	14
303	3	30	88	24	17	30	7
304	3	31	88	20	17	21	10
305	4	1	88	24	19	34	13
306	4	2	88	24	20	32	16
307	4	3	88	26	21	36	16
308	4	4	88	26	20	32	12
309	4	5	88	27	20	42	14
310	4	6	88	26	20	30	11
311	4	7	88	24	17	29	6
312	4	8	88	22	16	30	6
313	4	9	88	26	19	33	8
314	4	10	88	27	20	30	10
315	4	11	88	26	15	29	2
316	4	12	88	22	13	26	4
317	4	13	88	25	15	33	4
318	4	14	88	25	19	36	7
319	4	15	88	27	22	36	10
320	4	16	88	27	21	37	10
321	4	17	88	26	22	31	10
322	4	18	88	28	23	33	13
323	4	19	88	26	20	31	9
324	4	20	88	25	19	32	4
325	4	21	88	27	22	36	12
326	4	22	88	27	24	37	17
327	4	23	88	27	24	31	18
328	4	24	88	27	22	27	12
329	4	25	88	26	22	40	12
330	4	26	88	26	22	32	10

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
331	4	27	88	27	21	40	12
332	4	28	88	25	20	36	6
333	4	29	88	24	20	38	7
334	4	30	88	24	22	29	11
335	5	1	88	26	21	40	4
336	5	2	88	26	21	39	7
337	5	3	88	27	23	37	13
338	5	4	88	27	23	29	10
339	5	5	88	26	22	40	9
340	5	6	88	26	22	32	8
341	5	7	88	27	22	38	10
342	5	8	88	26	23	32	13
343	5	9	88	28	24	38	17
344	5	10	88	28	24	39	19
345	5	11	88	28	24	41	10
346	5	12	88	28	23	39	14
347	5	13	88	27	23	31	12
348	5	14	88	28	24	37	13
349	5	15	88	29	24	44	13
350	5	16	88	28	24	39	16
351	5	17	88	28	24	39	14
352	5	18	88	28	23	38	10
353	5	19	88	28	23	42	11
354	5	20	88	28	24	43	13
355	5	21	88	28	25	26	17
356	5	22	88	27	24	26	14
357	5	23	88	27	23	31	13
358	5	24	88	27	24	38	17
359	5	25	88	26	23	32	14
360	5	26	88	27	22	38	9
361	5	27	88	27	23	42	10
362	5	28	88	28	24	43	12
363	5	29	88	27	24	41	11
364	5	30	88	28	24	42	12
365	5	31	88	28	24	44	14
366	6	1	88	29	24	42	14
367	6	2	88	28	25	39	17
368	6	3	88	28	24	38	17
369	6	4	88	27	24	33	18
370	6	5	88	27	24	37	17
371	6	6	88	27	24	40	14
372	6	7	88	28	25	41	17
373	6	8	88	28	25	43	16
374	6	9	88	29	25	41	21
375	6	10	88	27	24	34	14
376	6	11	88	28	23	41	10
377	6	12	88	27	23	33	10
378	6	13	88	28	24	43	14
379	6	14	88	28	25	44	14
380	6	15	88	28	24	43	14
381	6	16	88	29	25	46	16
382	6	17	88	29	25	38	17
383	6	18	88	29	25	38	19
384	6	19	88	28	24	34	16
385	6	20	88	28	24	41	16

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
386	6	21	88	28	24	44	18
387	6	22	88	27	24	32	18
388	6	23	88	28	25	42	18
389	6	24	88	28	25	42	21
390	6	25	88	28	25	34	20
391	6	26	88	28	25	39	20
392	6	27	88	29	26	41	22
393	6	28	88	29	25	47	18
394	6	29	88	29	25	49	16
395	6	30	88	30	26	44	22
396	7	1	88	30	26	42	22
397	7	2	88	30	26	43	21
398	7	3	88	30	26	41	21
399	7	4	88	29	25	37	18
400	7	5	88	29	25	31	20
401	7	6	88	28	25	34	19
402	7	7	88	28	25	32	20
403	7	8	88	28	25	41	17
404	7	9	88	30	25	39	17
405	7	10	88	29	26	38	21
406	7	11	88	29	26	36	24
407	7	12	88	29	26	35	22
408	7	13	88	28	26	33	23
409	7	14	88	29	26	39	22
410	7	15	88	30	26	43	21
411	7	16	88	31	26	41	22
412	7	17	88	30	25	37	20
413	7	18	88	29	24	36	21
414	7	19	88	29	26	37	22
415	7	20	88	29	25	34	20
416	7	21	88	29	25	38	21
417	7	22	88	29	26	37	20
418	7	23	88	28	25	44	16
419	7	24	88	28	25	44	14
420	7	25	88	28	25	47	18
421	7	26	88	27	25	22	21
422	7	27	88	27	23	38	19
423	7	28	88	28	26	33	19
424	7	29	88	29	25	39	18
425	7	30	88	28	26	39	19
426	7	31	88	28	25	39	19
427	8	1	88	28	26	35	19
428	8	2	88	28	26	43	26
429	8	3	88	28	25	36	20
430	8	4	88	28	25	40	19
431	8	5	88	28	26	39	20
432	8	6	88	28	25	40	20
433	8	7	88	28	25	43	21
434	8	8	88	29	25	42	20
435	8	9	88	29	25	42	21
436	8	10	88	28	25	38	21
437	8	11	88	29	25	41	20
438	8	12	88	29	25	42	20
439	8	13	88	30	25	38	20
440	8	14	88	29	25	36	20

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
441	8	15	88	29	26	40	21
442	8	16	88	29	26	39	21
443	8	17	88	29	25	36	21
444	8	18	88	29	25	40	20
445	8	19	88	29	26	32	21
446	8	20	88	29	26	40	21
447	8	21	88	30	25	39	18
448	8	22	88	29	24	38	19
449	8	23	88	29	25	38	21
450	8	24	88	29	26	38	21
451	8	25	88	30	25	40	16
452	8	26	88	30	26	38	18
453	8	27	88	30	26	42	20
454	8	28	88	30	26	39	20
455	8	29	88	30	25	40	20
456	8	30	88	28	25	33	18
457	8	31	88	29	24	39	17
458	9	1	88	30	25	39	19
459	9	2	88	30	25	34	19
460	9	3	88	29	25	37	19
461	9	4	88	28	25	29	19
462	9	5	88	28	24	34	12
463	9	6	88	27	23	34	13
464	9	7	88	26	20	33	11
465	9	8	88	27	22	37	10
466	9	9	88	28	24	38	12
467	9	10	88	29	24	40	23
468	9	11	88	29	24	37	23
469	9	12	88	28	25	37	19
470	9	13	88	29	25	38	18
471	9	14	88	29	25	43	19
472	9	15	88	30	25	43	20
473	9	16	88	29	25	28	20
474	9	17	88	30	25	37	20
475	9	18	88	30	26	38	20
476	9	19	88	30	26	41	20
477	9	20	88	30	26	37	21
478	9	21	88	31	25	42	19
479	9	22	88	31	26	38	19
480	9	23	88	31	25	39	20
481	9	24	88	31	26	39	20
482	9	25	88	30	26	37	20
483	9	26	88	29	24	33	16
484	9	27	88	29	24	40	20
485	9	28	88	29	24	42	18
486	9	29	88	29	25	41	18
487	9	30	88	29	25	41	17
488	10	1	88	28	24	28	17
489	10	2	88	26	23	23	13
490	10	3	88	27	23	33	12
491	10	4	88	26	23	31	9
492	10	5	88	26	22	31	9
493	10	6	88	25	21	30	6
494	10	7	88	25	21	30	6
495	10	8	88	25	22	33	9

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
496	10	9	88	25	22	19	10
497	10	10	88	25	22	18	9
498	10	11	88	25	21	32	7
499	10	12	88	26	22	30	4
500	10	13	88	25	21	30	2
501	10	14	88	24	20	33	2
502	10	15	88	25	21	33	3
503	10	16	88	25	22	33	9
504	10	17	88	26	23	31	12
505	10	18	88	27	23	34	13
506	10	19	88	27	23	37	13
507	10	20	88	25	22	18	11
508	10	21	88	24	21	28	10
509	10	22	88	25	21	37	4
510	10	23	88	26	22	38	7
511	10	24	88	25	22	30	8
512	10	25	88	25	21	36	4
513	10	26	88	25	22	33	11
514	10	27	88	25	22	31	11
515	10	28	88	26	24	34	13
516	10	29	88	24	22	24	10
517	10	30	88	24	22	19	10
518	10	31	88	23	20	16	7
519	11	1	88	23	20	29	2
520	11	2	88	24	20	30	2
521	11	3	88	25	22	29	12
522	11	4	88	25	23	29	12
523	11	5	88	25	22	24	7
524	11	6	88	24	20	23	6
525	11	7	88	22	19	28	1
526	11	8	88	25	22	28	17
527	11	9	88	25	22	33	13
528	11	10	88	25	20	31	17
529	11	11	88	22	17	24	6
530	11	12	88	22	17	29	11
531	11	13	88	21	18	22	10
532	11	14	88	30	19	33	7
533	11	15	88	24	22	30	14
534	11	16	88	23	18	12	9
535	11	17	88	20	16	24	1
536	11	19	88	21	16	24	3
537	11	20	88	24	20	30	18
538	11	21	88	24	18	29	4
539	11	22	88	19	15	21	4
540	11	23	88	17	14	21	1
541	11	24	88	19	14	27	-1
542	11	25	88	20	15	29	-2
543	11	26	88	21	17	22	9
544	11	27	88	21	20	21	12
545	11	28	88	21	19	14	7
546	11	29	88	19	15	17	0
547	11	30	88	18	15	23	-4
548	12	1	88	20	16	24	-4
549	12	2	88	18	15	17	-3
550	12	3	88	19	15	28	-3

OBS	MONTH	DAY	YEAR	WMAX	WMIN	AMAX	AMIN
551	12	4	88	20	15	26	-3
552	12	5	88	19	16	19	0
553	12	6	88	19	15	23	-5
554	12	7	88	18	14	21	-6
555	12	8	88	19	15	28	-2
556	12	9	88	19	17	19	4
557	12	10	88	19	17	8	1
558	12	11	88	18	16	17	-1
559	12	12	88	18	16	17	-1
560	12	13	88	16	13	14	-3